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Forthcoming Events.

JUNE 4-5.

British Empire Mining and Metallurgical Conference.—At Wembley.

JUNE 4 to 6.

Institute of British Foundrymen.—Annual Convention at Newcastle.

JUNE 19 to 28.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

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Sheffield: R. Village, Albion Foundry, Whittington Moor, near Chesterfield.
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Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

The Newcastle Congress.

The Newcastle Conference has now assumed something of international importance, for numerous foreigners are inquiring as to the possibilities of their attendance. Surely, if it is worth while to them to make quite long journeys from overseas, it is sheer foolishness on the part of British foundrymen not to make a really serious endeavour to spend a few days on the Tyneside. We have heard a few reasons from Southern foundrymen why it is difficult for them to be present owing to the proximity of Whitsuntide, but we have yet to hear a proper reasoning placing the advantages on one side and the difficulties on the other. The difficulties are but temporary and passing, whilst the advantages are permanent, and can be enumerated. Primarily, no foundryman can afford to get out of date, and the meeting of experts from all over the country affords ample opportunity, if not during the discussion of Papers, then on the numerous other occasions, of obtaining information as to the latest trend of metallurgical thought, of the behaviour of novel plant, and of the progress of new foundry alloys. The presence of foreign foundrymen makes possible the comparison of local methods and conditions with foreign ones. Of all foundry congresses ever held none has ever had a better framework than that arranged by the Newcastle Convention Committee. To our mind it is difficult to realise why at least 50 per cent. of the members of the Institute of British Foundrymen should not take part in these annual conferences. It is very pointed, on examining the lists of those present at previous conferences, that the most modern foundries are invariably the best represented. Unless the balance take a more enlightened view of foundry technology they will deteriorate and occupy a similar position in the foundry world to that assumed by a country blacksmith's shop in the engineering industries. It is of vital importance to the foundry industry that every unit which constitutes it, should take a personal interest in its technical development. Every foundry has a wonderful birthright in that it is dependent on no particular industry for its business. *But this is seldom realised.* Foundries have specialised so that to-day they cater for *one*, and usually *one only*, of the following industries: marine engineering, textile, stove grate, builders castings, railway work, automobile engineering, general engineering, light engineering, pipe founding, electrical engineering. The foundry *which has the requisite technical knowledge* can cater for several trades. Herein lies a very good reason why such a chance as the Newcastle Conference presents, should not be missed by any foundry owner. He should devote much thought to this subject because, apart from variations in trade, there are several industries which have seasons, and by having several strings to one's bow an equalisation of output should be obtained. This is a question which can only be tackled by those who have sufficient confidence in their technical ability to enable them to embrace types of castings other than those for which their works have been developed.

Transverse Test-Bars and Engineering Formulæ.

In the Paper bearing the above title, submitted by Messrs. Gerald S. Bell and C. H. Adamson at the recent annual meeting of the Iron and Steel Institute (see JOURNAL, May 8 issue, page 378), the authors criticised some of the generally accepted engineering formulæ, pointing out that those for the conversion of the transverse test on one sized bar to that on another sized bar do not hold when applied to cast-iron test-bars of different sizes. In their conclusions they remarked also that a study of the fractures and micro-sections of the bars they had tested had led them to the conclusion that, while structure has a great influence on mechanical tests, the engineering formulæ (some of which date back to the early part of last century) do not take this into account. The discussion which followed the reading of the Paper centred round those criticisms to a considerable extent, and we append a report of it.

DR. L. AITCHISON said the results obtained by the authors were not very surprising, as it seemed to him that they were using formulæ originally intended to apply to metals which were stressed only up to their elastic limit for stresses which were considerably greater than the elastic limit; in fact, which were the breaking strengths. If the bars used by the authors were of very considerable difference in section, as apparently they were, the formulæ were not likely to apply unless the neutral axis was distributed in the different-sized bars in similar positions. That would only follow if the material had a constant, or approximately constant, modulus of elasticity. Cast-iron was not a material of that type, and such determinations as had been made, even at comparatively low stresses, showed that that modulus varied by perhaps 50 per cent. between the minimum and maximum values. He noticed that the authors cast some doubt on the formulæ owing to their age, but he did not know that formulæ dating from the beginning of the last century need necessarily be blown upon in that way; they were not really intended to be accurate if applied to different sizes of materials. A further point was with regard to the effect of machining. It might be expected that there would be some difference in the results and that it would be possible to obtain a more satisfactory result when the outer surface was removed. If the material had an unsatisfactory inconstant degree of elasticity, the rough condition of the surface would be affected, because there would be a good deal of plastic distortion at the bottom of the irregularities on the surface, and it was only by the consistent removal of such irregularities that one could expect to get even comparatively consistent results. Another point was that, despite the experience of the authors, there was one set of conditions under which formulæ somewhat similar to those used had been found to be very variable, namely, in the testing of piston rings, which in the past, he thought, were tested on the tensile strength of a separately cast test-piece, or a test-piece which was merely an extension of the cylinder cast for the rings. That practice was now being abandoned in favour of testing an actual ring cut out from the piston-ring pot, and a formula which was naturally related to the ones the authors had mentioned in their Paper gave very consistent results on the sizes of pot which were used for that class of work. He agreed that it was not reasonable to expect that formulæ should give consistent results when applied to vastly different sizes, as was suggested in the Paper.

MR. EBENEZER ADAMSON thought the last speaker scarcely gave the authors credit for the fact that they were referring in their research to engineering castings and not to piston-pot rings; the latter were small in thickness, and therefore the chill in rapid cooling made very little difference in the size of the grain. The work of the authors was in connection with engineering castings which varied in thickness from 1 in. up to a few inches, and the test-bars used were those which had been in constant use in the engineering trade for a considerable period. His (the speaker's) experience of cast-iron extended now over a period of probably 30 years. Years ago, from the irregular results he was constantly getting, he came to the conclusion that chemical analysis played only a very small part in the tests of cast-iron. As a result of his own researches, he came to the conclusion that the physical characteristics of cast-iron as disclosed in the fracture played the most prominent part, and that the analysis played a secondary part. The slightest variation in conditions, right away from melting iron up to casting it, might alter the result. He was indebted to the authors for having confirmed the publication of a Paper that he (the speaker) had read before the Institute in 1909. It was based upon a statement from America that tensile and transverse test-bars tested as cast gave better results than when machined. He doubted that, and, the Central Marine Engine Works having placed their foundries at his disposal, he proved that when the bars were machined (just the skin machined off) there was obtained consistently round about 10 per cent. better results than when the bars were not machined. The results they had published were not going to enable the authors to form a definite formula, but possibly from the data which they would obtain from the continuation of the research they would be able to formulate some suggestion whereby the different transverse bars in heavy engine work could be transposed from one test to another.

MR. G. S. BELL, in reply, expressed regret that Dr. Aitchison should have the idea in his mind that the authors threw any doubt on the engineering formulæ simply on account of their age. The reference to the age of the formulæ was simply included as a statement of historical fact. At the same time, he was pleased that Dr. Aitchison recognised the complete inadequacy of the formulæ for dealing with cast-iron bars. The formulæ were selected because they were the most widely used by practical engineers at the present time, and also because they were recommended as the most widely used from the engineering side of a University. The authors agreed as to the modulus of elasticity of cast-iron varying, but the main point was that the formulæ existed and had a wide use and application, as was well known, for definite facts. The authors entirely agreed as to the effect of machining on cast-iron test-bars, and would like to suggest further that what happened primarily was that the machining—and grinding must not be forgotten—by removing the irregularities increased the transverse strength, but would go beyond that and, as it were, open the structure; in other words, there was a race between the removal of the irregularities and the opening of the structure by going further down into the bar, and that point was reached when the opening of the structure and its effect outweighed the removal of the irregularities by machining.

Obituary.

MR. C. E. L. BROWN, one of the founders of Brown, Boveri & Company, died on May 2.

MR. WILLIAM SPENCER, managing director of James Spencer & Company, Limited, Chamber Iron Works, Hollinwood, died on May 8, aged 67.

MR. JOHN MILLS, former principal of the firm of John Mills & Company, Railway Foundry, Llanidloes, Mont., died on Saturday, May 17. Mr. John Mills was in his eighty-first year, and though he had ceased for some time to take an active interest in business matters, he retained to the end many pleasant recollections of business associations, some of them extending over a period of more than half a century.

Personal.

MR. LEONARD ROPNER, J.P., the well-known Tees-side shipbuilder, has presented £10,000 to the extension fund of the Stockton and Thornaby Hospital.

LORD ABERCONWAY, who was knocked down by a taxicab recently, was fortunately not seriously hurt, and was not detained in hospital. He was able to proceed to his residence.

MR. LAWRENCE ENNIS, general manager of Dorman, Long & Company, Limited, Middlesbrough, who has just returned from Australia, where he has been in connection with the Sydney Bridge contract, has been elected by the directors of the firm to a seat on the board.

Wills.

COOPER, D. W., a director of Roberts & Cooper, Limited, and the Wollescote Galvanising Company	£13,688
GOOD, F., of The Croft, Beer, Devon, late general manager of the Bute Dry Docks and Engineering Company, Cardiff, (net personalty, £9,094)	£9,712
PEARSON, H., iron and steel merchant, of Haisthorpe Hall, Burton Agnes, Yorks, and chairman of the Sheffield Hollow Drill Company, Limited	£9,913

A PARTY OF prominent engineers, including Mr. R. A. Chattock, Mr. G. G. Bell, Mr. E. H. Cockshott and Mr. J. H. Millen (Underground Railway) and Mr. G. C. Usher and Mr. David Wilson (Vickers & International Combustion Engineering, Limited), left London recently for America in order to investigate the latest developments in power house design, and more particularly the application of powdered fuel to boilers. They visited the majority of modern power plants, and journeyed as far west as St. Louis.

Foundry Queries.

Sand Quantities and Coke Ratio.

The further letter from "G. F." giving details as to his cupola working enable some advice to be given. The question of coke consumption produces as many ratios as there are variables to be considered in deciding what is true economy in cupola melting. There are foundries in this country, known to the writer, who obtain regularly a melting ratio of 1 to 10; it must, however, be remembered that the ratio set up by one foundry is not of the least use to its neighbour as any guidance, so many considerations have to be taken into review. Details taken by the writer from a large number of foundries revealed the fact that the average ratio is about 1 to 8. The ratios in these foundries varied from 1 to 5, to as high as 1 to 11. It should always be understood whether the ratio includes the whole of the coke consumed, including the coke bed. The latter is very often left out.

The ratio of consumption is very largely governed by the size of the cupola, its position in the foundry, height of the tuyeres and, above all, the quality of the coke. An economic rate of coke burning (90 per cent. carbon, 10 per cent. ash or moisture) for a 32-in. cupola per hour would be about 890 lbs. Its melting capacity per hour is 72 cwts.

"G. F." has in his cupola two rows of tuyeres. The writer is convinced that the use of upper tuyeres is not only unnecessary, but a positive detriment to the production of good metal. It will repay "G. F." to test his cupola by at least temporarily closing the upper row and increasing the lower row to six tuyeres; the total tuyere area should be 148 sq. ins. as at present. The air pressure required is 8 to 10 ozs. per sq. in., and the velocity through the tuyeres 29 ft. per sec.

With regard to "G. F.'s" inquiry as to facing sand mixtures, this is a matter that depends upon the nature of the sand to be used and the moulder's judgment of what is required for his particular job. The proportions of facing sands vary very much in different foundries. The following mixtures can be tried by "G. F." for light castings:—Red sand, 20 per cent.; rock sand, 10 per cent.; floor sand, 60 per cent.; fireclay, 10 per cent.; with about 10 per cent. fine coal dust added. For heavy or medium castings: Red sand, 50 per cent.; floor sand, 20 per cent.; fireclay, 20 per cent.; coal dust, 10 per cent. Of course, it is understood that the mould surface is swabbed with a thin wash of plumbago and air-dried before casting.

DISCE DOSCE.

Cold Metal.

Being in the district, I would like to see J. R. R.'s cupola, as I fail to appreciate the two 6½-in. tuyeres. He gets 30,000 cub. ft. of air through the cupola in 15 min., which is sufficient to melt 1 ton of iron. I believe that the 4½-in. dia. pipe from the fan to the air belt is too small, taking into consideration that the fan outlet is 5 in. dia.

The charges—that of 5 cwt. of iron to 60 lbs. of coke, or roughly, 9 to 1—may be insufficient, as he requires hot metal. After all, one cannot melt iron without coke. The height of the stack will govern, in a small cupola, the coke bed, but I consider 2 ft. 8 in. is too high. It would be interesting to know the time which elapses before the first metal appears.

If J. R. R. were a member of the Institute of British Foundrymen he would have been able to obtain this advice from several of the Bolton members. I shall be pleased to show J. R. R. local cupolas—a 5-ton, 3-ton and 1-ton per hour—which are over 100 years old, and which regularly produce iron sufficiently hot for any job. As with the majority of Institute men, I shall be pleased to give him the benefit of my experience.

A. SUTCLIFFE.

1, Firwood Grove, Tonge Moor, Bolton.

THE WENVOE IRON ORE COMPANY, LIMITED, are being wound up voluntarily with a view of reconstruction. Mr. D. Percy Jones, Taff Street, Pontypridd, the secretary of the company, has been appointed liquidator.

The Late Mr. W. H. Cook.

As briefly announced in our last issue, the Lancashire Branch of the Institute of British Foundrymen has suffered a severe loss by the death of Mr. W. H. Cook, M.I.M.E., who died at his residence at Heaton Chapel, Manchester, on May 15.

Mr. Cook was born at Stalybridge in 1861, and was educated locally, serving his apprenticeship as a mechanical engineer with Messrs. Taylor, Lang & Company, at the same time gaining the medals for all England in mechanical engineering and cotton spinning. He was appointed works manager to Messrs. Brooks & Doxey, Union Ironworks, Manchester, and on resigning practised as a consulting engineer, visiting India from 1911 to 1913. During the war, in conjunction with his brother, his whole time was devoted to war work with the firm of Spencer & Cook, Limited, Stalybridge. At the time of his death he was chairman of the directors of Messrs. Taylor, Lang & Company, Limited.

Mr. Cook was a member of numerous technical societies, and was the author of many papers on engineering and foundry subjects, for one of which, in conjunction with Mr. Joseph Stubbs, he received the Constantine Gold Medal of the Manchester Association of Engineers. He had been a member of the General Council of the Institute of British Foundrymen, and also of the Council of the Lancashire Branch.

In his younger days he was a successful teacher of engineering subjects, and for many years examiner to the City and Guilds of London Institute in Cotton Spinning.

Mr. Cook was a widower, and is survived by a son, Mr. W. Norman Cook, B.Sc., and by two daughters.

Contracts Open.

Johannesburg, June 16.—Solid drawn copper tubing, for the South African Railways and Harbours. The Department of Overseas Trade (Room 49).

Kirkconnel, Dumfries, June 7.—Supply and laying of about 560 yards of 3-in. and 2-in. cast-iron water mains for the Thornhill District Committee. Mr. W. C. Easton, 183, West George Street, Glasgow. (Fee, £1 1s., returnable.)

Nantwich, June 4.—7,550 yards of 6-in. cast-iron "spun" pipes, branches and other pieces, for the Nantwich R.D.C. Mr. H. Crabtree, engineer, 1, Dysart Buildings, Nantwich. (Fee, 10s., returnable.)

Swallowfield, near Wokingham, June 9.—Supply and laying of about 4,933 yards of 4-in. water main, sluice valves, etc., for the Wokingham R.D.C. Mr. P. H. Phipps, clerk, Barkham Road, Wokingham. (Fee, £1, returnable.)

Antwerp, June 26.—Supply, delivery and erection of 15 electrically-operated Portal cranes each of three metric tons capacity on the No. 3 dock of the "Quai du Nord." The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Bristol, June 9.—Supply and erection of three two-ton movable electric jib cranes, for the Docks Committee. Mr. T. A. Peace, engineer, Avonmouth Dock, Bristol. (Fee, £5, returnable.)

Manchester, June 16.—Steel constructional work, for the Tramways Committee. The City Architect, Town Hall. (Fee, £1 1s., returnable.)

Patent Abstracts.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2, and Commerce Chambers, Parliament Street, Nottingham. Printed copies of the specifications in the following list are now on sale.

215,495. BENJAMIN, G. H.—Furnaces for melting and casting.

215,518. HOSACK, H. H.—Pouring or casting of metal into ingot and similar kinds of metal moulds.

215,522. ELLIS, G. B.—Die-casting and similar operations.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

"Low-Temperature Reduction of Iron Ore."

To the Editor of The Foundry Trade Journal.

Sir,—I would venture to beg the opportunity of replying to the criticisms of Major Miles upon the general statements made in my article published by yourself on the Low-Temperature Reduction of Iron Ore.

Time alone can show the exact period which will elapse before there comes a very general adoption of the low-temperature principle. My knowledge of the innate sagacity of steel makers was the sole cause of my endeavouring to put the short limit of ten years upon it. Possibly my mental allowance for "moment of inertia" was insufficient; certainly in my view the practice of low-temperature principles on a scale commensurate with modern demands as to quantity and price must and will come in the reasonably early future.

I had hoped that I had taken particular pains to emphasise the fact that the actual reduction in a blast furnace was done in a low-temperature zone, so that by inference the subsequent practical series of events taking place in it was dictated by motives of convenience or of "practical politics."

Primarily, let me say, that I approached this subject with a close technical and practical experience of iron and steel metallurgy extending for upwards of 30 years, and that for very many years past I—in common with most other introspective iron-metallurgists—have taken very deep interest in low-temperature iron reduction both as to principles and efforts.

My name has been mentioned in connection with the Hornsey process; I hasten to disclaim any share of the very real credit that must be given to that practical process, with whose product I am now familiar, and in connection with which product I *do* claim laudable achievement.

Claims as to past prophecy are wont not gratefully to be received, but even at this risk I claim that the most extravagant prophecies which I made concerning the attributes of Low-Temperature Reduced Iron—prophecies attributed at the time to "crank" ideas—have been more than fulfilled as the result of my conversion into steel of the low-temperature product which resulted from the operation of the Hornsey process.

Major Miles appears to regard me as a violent antagonist of the blast furnace. In so doing he is wrong, for no one can have greater admiration for that highly developed metallurgical instrument than I have. But its product is essentially an iron alloy; true, in certain directions the very defects of the iron alloy prove to be its virtues; as a steel making intermediate, however, it is but a clumsy expedient, except in those minimum quantities which for other reasons may be rendered necessary. In this connection I cannot do better than quote my own published words:—

> "Let it definitely be stated that the iron product of the blast furnace must and always will have an enormous sphere of utility in industrial legitimate requirements" (the manufacture of all cast iron articles) "nor in any process of steel making involving the use of a gas-fired open hearth can it be dispensed with *entirely*. Obviously a pneumatic process of steel manufacture must work upon pig-iron or its equivalent, since the reactions required must be exo-thermic in their nature; in a steel-making process conducted upon an electrically-heated hearth or in the crucible, pig-iron is not required—nor in the latter case is it indeed admissible—as to the main steel source."

I have neither need nor desire to retract one word of this; notwithstanding, I visualise an industrial field—staggering in its immensity—awaiting legitimate occupation by "low-temperature" iron.

I must completely join issue with Major Miles when he says that "the best lines of advance in both cases seem to be made in perfecting the existing appliances." Such a trend of opinion would have effectually barred the work of Huntsman, of Bessemer, and of Siemens.

The discussion of individual items of cost is obviously not in my province, but I completely fail to see why the labour cost attached to a ton of low-temperature metallic product should be as high as that incidental to the blast furnace, why the wear and tear should be anything approaching it, why works general capital and depreciation charges should not substantially be lowered, why a low-temperature reduction plant should not supply its own motive power and why there should not be decreases rather than increases in "off" grades. As to the last-mentioned, I speak with painful knowledge of the vagaries of the blast furnace. In this connection it is interesting to note that the question of his own cost details was entered into somewhat fully by Mr. John W. Hornsey in an interview which he gave to and was published by the "Sheffield Telegraph and Star." It was naturally pleasing to me to note that my impressions had been substantiated by his experiences.

Naturally I agree that silicides, sulphides and phosphides of iron exist at low temperature; the actual point seems to me to be that silicates and phosphates are not *reduced* at low temperatures. Therefore I still adhere to the contention of blast-furnace owners advantageously possessing an auxiliary low-temperature reduction plant for dealing with dead-fine ores.

I understand that one of the great claims of low-temperature process operators is that they have much greater control over their plant than it is possible to exercise over a blast furnace, while to one who has studied the subject it is extremely difficult to imagine how capital outlay can fail to be much smaller in the case of a low-temperature reduction plant than in the case of a blast-furnace outfit of equal capacity.

I heartily agree with Major Miles that the blast-furnace plant of this country cannot be described generally as up-to-date, though there are very many notable exceptions. I am also in agreement with him when he talks of the length of time which is necessary for the effecting of any radical alteration of existing methods. I myself was intimately connected with by-product coking in the earlier days of its British inception, and have very live recollections of the attitude of the average blast-furnace manager towards its product. The opinions which he expressed would to-day merely be described as "behind the times;" then his position rather was regarded as that of a doughty warrior, firmly entrenched, warding off the onslaughts of incompetent iconoclasts.

It is the business of the scientist accurately to realise potential obstacles. Where such are fully visualised and do not seem at all insurmountable it would be deplorable to retard economic progress by despairing adherence to "ancient shibboleths." In those portions of my article which dealt with practical matters I was talking, not of what may be accomplished, but, of what has been done.—Yours, etc.,

J. Kent Smith.

1, Staniforth Road,
Attercliffe, Sheffield.
May 23, 1924.

Lancashire Foundrymen visit Textile Machinery Works.

On Saturday, May 17, about 130 members of the Lancashire Branch of the Institute of British Foundrymen visited the foundries of Messrs. Howard & Bullough, Limited, textile machinery manufacturers, Accrington. This company operates three large foundries, which are equipped for dealing on a repetition basis with the castings required by the Company for its various lines of manufacture. The visitors were much impressed by the lay-out of the foundries and by the numerous special moulding appliances which are in use.

At the conclusion of the visit the visitors were entertained to tea by the Company. After tea an enthusiastic vote of thanks was accorded Messrs. Howard & Bullough, Limited, and their staff, on the motion of the Branch President, Mr. R. A. Miles, seconded by the Branch Secretary, Mr. T. Mackemson.

Non-Magnetic Cast Iron.*

By S. E. Dawson, A.I.C.

In considering cast iron as applied to industry one is struck by the comparatively small field in which it is utilised. Up to recent years it was only considered where bulk and relative low mechanical and electrical properties were called for, but of late years, and due largely to a closer investigation of its potential possibilities, it has been to some extent raised out of this category. By the attainment of increased mechanical strength, by a better understanding of its electrical and magnetical properties, and by the more accurate production of castings to absolute dimensions and design, it is not now so lightly cast aside in favour of steel, bronze, etc.

As applied to the electrical industry its fundamental drawback was that it was magnetic to a greater extent than any other metal, but even this feature has now been overcome, so that we have a metal which at once becomes a competitor of brass, aluminium and other non-magnetic materials.

During the last few years cast iron has there-

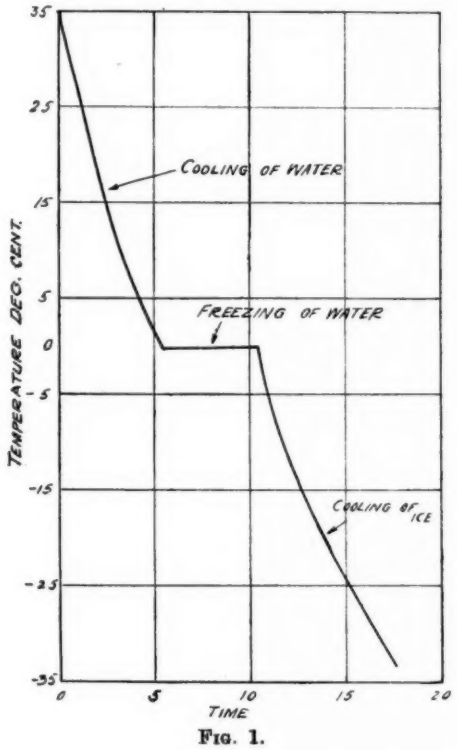

FIG. 1.

fore entered into many fields for which it had previously not been considered, for one or other of the above reasons, and as further investigations which are now in hand develop it may be hoped that cast iron will obtain the consideration that it merits for industrial purposes.

Improvements in cast iron are being actively sought for by the British Cast Iron Research Association, as well as by private research students, and the placing of standard specifications for all types and uses of cast iron on a firm footing will materially help in this direction.

The average engineer knows little about cast iron beyond the chemical analysis, but as the usual method of expressing this is merely a statement of the "ultimate" content of various elements in which form, as a matter of fact, they do not in the majority of cases exist, no measure of the actual components of cast iron is indicated.

Each of the elements found by analysis are capable of combining separately with one another to form compounds which, as in the case of most inorganic compounds or salts, have properties and characteristics distinct from the individual elements. It is thus evident that the actual effect of the component parts of cast iron, other than pure iron, may be vastly different from that of the individual elements, and with some of these this is actually the case.

Phosphorus, for example, could not exist separately in cast iron for obvious reasons. In the form of phosphide of iron, however, it can and does exist, and since this substance is very brittle and hard it constitutes a possible source of great trouble in the machine shops if not kept under very careful control as to its disposition throughout the metal. This compound of phosphide of iron has other features which, as will be seen presently, have a profound influence on cast iron. The effect, therefore, of a small percentage of phosphorus as revealed by the ordinary chemical analysis assumes a different aspect when viewed in the light of its effect as phosphide of iron, since the latter compound is approximately $6\frac{1}{2}$ times $(\frac{100}{31})$ that of the phosphorus content.

In the same way carbon, when combined with iron, form a compound about 15 times greater than the element itself, and as this carbide of iron is a hard material its effect might be, and sometimes is, very disastrous.

To visualise the compositions of a cast iron, one might usefully place side by side the chemical analysis as found in the laboratory, and the proportion of compounds derived therefrom by calculation. This is done in Table I.

TABLE I.—*The Ultimate and Rational Analyses of Cast Iron.*

	Ultimate analysis per cent.		Rational analysis per cent.	
Graphite Carbon	2.70	giving	2.7	Graphite.
Combined ,,	0.75	,,	11.2	Carbide of iron (Fe_3C).
Silicon	2.33	,,	7.0	Silicide of iron (FeSi).
Manganese ..	0.60	,,	0.6	
Phosphorus ..	1.10	,,	7.1	Phosphide of iron (Fe_3P).
Sulphur	0.08	,,	0.2	Sulphide of iron (FeS_2).
Total ..	7.56		28.8	

The manganese would be present as carbide or sulphide, but to avoid complications for comparison here, these latter are shown as all combined with iron and the manganese left as if free, though actually it would take the place of the iron similarly combined, but this arrangement will make little difference in the above figures.

The effect of 28 per cent. of compounds other than iron, and each with characteristics of their own, and differing greatly from iron itself, allows one to realise the importance of the "foreign" elements present in cast iron.

The Effect and Distribution of Constituents.

Having thus considered the vast possibilities for differences of cast iron, it is useful to investigate the effect of the various constituents, and the means of determining the manner in which they are located or distributed, so as to arrive at their probable effect on the mass as a whole. This is a matter which concerns all alloys and study of the equilibrium of mixed metals affords valuable information, which, when applied to cast iron, explains many of the problems which are met with in the foundry and machine shops.

On adding one liquid metal to another, the resultant mixture is usually homogeneous so long as the mixture remains liquid. The alloy, however, after solidification, may have more than one constituent from a structural point of view. Some of these various constituents, unlike chemical compounds, are not necessarily composed of the elements combined together in definite ratios and

* Presented before the Lancashire Branch of the Institute of British Foundrymen, Mr. R. A. Miles presiding.

moreover vary with the physical conditions which have prevailed during the cooling-down period, and may further vary at a later stage even when solid by mechanical action.

When the alloy produced by adding one metal to another forms a homogeneous solution, the one resulting constituent is called a solid solution. In an alloy, then, there may be three constituents: —(*a*) A pure metal; (*b*) a chemical compound; and (*c*) a solid solution, and these may all exist at one and the same time in the same alloy.

The chemical compounds, however, do not always follow the law of valency, and may be considered more as molecular compounds, which are capable of being dissociated by conditions. They are not too powerfully united together, and unlike atomic chemical compounds, they do not differ greatly in appearance and properties from their component elements.

In the case of solid solutions, here, again, the forces holding the components together are relatively feeble, and each can be recovered by suitable mechanical or physical means, so that the appearance and properties of a solid solution are not very different from the individual parts dissolved in each other, and also solid solution like liquid solution does not take place in any fixed ratio. When we thus see what an alloy might consist of, the next step is to adopt means to investigate these conditions.

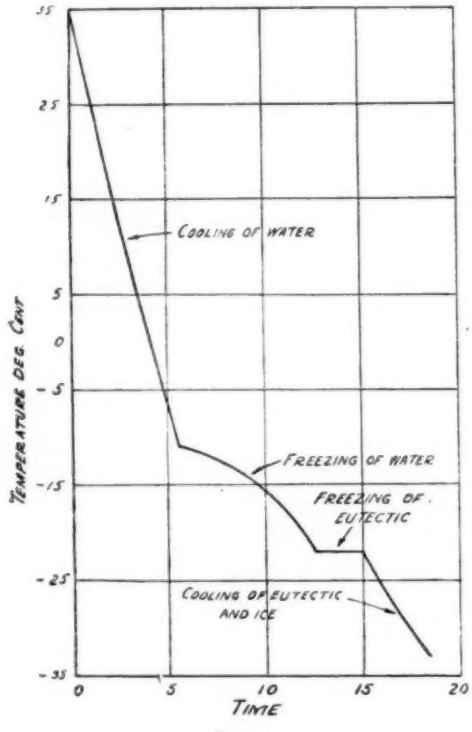

Fig. 2.

In investigating an alloy, then, means must be adopted to determine the proportion and characteristics of each of the constituents which may be present, and in producing a definite alloy an endeavour must be made to introduce the constituents in such a form as to give to the alloy the properties sought.

Chemical analysis, as already explained, whilst being the starting point or foundation of any investigation does not carry one very far towards the conception of the structure of an alloy, and one has to supplement the knowledge thus gained by other means. Microscopic examination marked a great advance in thus investigating alloys, but perhaps more direct knowledge can be obtained by an examination of their cooling curves.

To illustrate the usefulness of an investigation into the cooling curves of an alloy, we might consider the case of a pure metal, and to crystallise our thoughts on this also take the parallel case of a similar combination of common occurrence, namely, the cooling of ice and water.

When a mass of water is caused to cool down through its freezing point, the rate at which its temperature falls becomes slower and slower, that is, the curve takes the form of a hyperbolic curve, as shown in Fig. 2. This curve will be quite even or smooth until a temperature of 0 deg. C. is reached, when the temperature will remain constant until all the water has solidified, after which the fall in temperature will continue until that of the cooling medium is reached.

This retardation in the cooling curve is due to a certain small amount of heat which is liberated in the water passing from the liquid to the solid state. This same phenomena occurs similarly when a metal or alloy undergoes any physical change, and, indeed, when it undergoes any change either chemical or physical whilst cooling down. For example, Fig. 2 might equally represent in general contour the cooling curve of any pure metal where only a change from the liquid to the solid state has taken place. Thus we see that the cooling curve gives an easy method of detecting a change taking place in a mass of metal when cooling down. To carry this further we might now take a parallel example of a binary alloy, that is an alloy of two components, and use the case of a solution of salt in water as our guide.

When a salt solution cools it does not freeze into a homogeneous mass of the same composition as the liquid solution as does pure water, but separates into the two components, water and salt, a fact known as selective freezing. Thus, the water first commences to freeze out to form more or less pure ice, leaving the salt to form a stronger solution or "mother-liquor" with the remaining water which, becoming more saline, and following the law of impurities, lowering the pure freezing point, has a lower ice freezing-out point still. This progressive enrichment of the salt solution continues until a temperature of —22 deg. C. is reached when the percentage of salt in the mother liquor becomes 23.6 per cent., and the whole mass freezes (since this is the percentage strength of lowest fusibility) without any regard to selection with a further retardation in the curve due to this further physical change. We thus get a curve as shown in Fig. 2, which again might equally represent the cooling curve of a simple binary alloy.

No matter what might be the percentage of salt in the solution, there is no further separation or freezing out of salt after this 23.6 per cent. point has been reached at a temperature of —22 deg. C., and any excess salt over and above this amount in the original solution freezes out before the retardation shown in Fig. 2. This percentage of solute to solvent is known as the eutectic (lowest melting), and is the most fusible part of the mass. Thus in some alloys there is a eutectic which has a constant composition, and which solidifies at a constant temperature.

In more complex alloys the eutectic may consist of a definite compound, interstratified with another metal, for example, cementite (Fe_3C) interstratified with pure iron in steel, or phosphide of iron (Fe_3P) interstratified with a solid solution of phosphide of iron in cast iron.

These considerations are all assuming that the conditions of cooling have been such as to allow all the changes to take place fully before a subsequent effect has commenced, and in investigating an alloy by this method the cooling must be sufficiently slow as to allow of the temperature change points recorded to be a true criterion of the full changes taking place.

These interstratified plates are capable, under certain conditions of heat treatment, of partial transfusion or segregation, and this may also take place during the cooling down of an alloy if the conditions are sufficiently prolonged to allow it to occur.

It will be clear from the previous remarks that the eutectic is the last constituent of an alloy to solidify, and that it will, due to the earlier crystallisation of the excess metal (that is, the excess over eutectic requirements), be found in between and round those crystals. As this earlier crystallisation takes place the tendency is for the still molten eutectic to be squeezed forward in the direction of solidification or cooling, that is, from the outside of an ingot or casting to the portion of biggest mass, incidentally taking advantage of any

cavity due to shrinkage or other causes which it can occupy.

Phosphide Eutectic.

Now, in the case of cast iron the eutectic of lowest fusibility is a solution of phosphide of iron (Fe_3P) in pure iron, and this can be distinctly traced under the microscope and also by a careful chemical analysis, using the percentage of phosphorus as our guide. This squeezing out of the phosphide eutectic during the cooling down period is easily seen in the case of pig-iron, especially those which give a comparatively large proportion of eutectic, that is, the high phosphorus irons.

Here we find that the phosphide-bearing eutectic has been squeezed towards the centre of the pig so that the phosphorus content of phosphoric pig may be 2 per cent. at the centre whilst an average analysis may be only 1.5 per cent. This indicates the importance to be attached to the manner of drilling when sampling pig-iron for testing purpose. If taken down the centre of the pig from a fractured surface across the bar we shall certainly get a higher phosphorus content than taking drillings from the outside across the bar to the centre, and for complete control of the casting produced in the foundry it is essential to obtain a correct average sampling of all the constituents in the pig-iron and not drill into one section where we may expect a migration of the eutectic to have taken place.

When we consider that the phosphide eutectic in cast iron contains about 6 per cent. of phosphorus, we realise to what extent the eutectic itself forms part of the whole cast iron, for if the whole of the phosphorus in a 1.5 per cent. iron were in this form we should have about 25 per cent. phosphide eutectic, a quantity which may exert a profound influence on the structure as a whole. In foundry practice one does actually find that this low melting, very brittle and weak eutectic influences cast iron to a remarkable degree since, as already explained, during the cooling down process it passes between the excess metal crystals, filling up all available space and thereby producing envelopes and pockets and weakening by separating the crystal structure to such an extent, especially when the casting is subjected to alternating temperatures in, say, a gas engine cylinder, that planes of cleavage developing into actual cracks are produced in the casting.

According to Stead * pure iron may retain in solid solution only about 1.7 per cent. phosphorus corresponding to 11 per cent. phosphide of iron (Fe_3P) and above this amount of phosphorus the phosphide separates as a eutectic whose melting point is 980 deg. C. In the case of the iron-carbon alloys, the carbon facilitates the separation of the phosphide eutectic as strikingly shown by Table II, which gives his results.

TABLE II.—*The Influence of Carbon on the Condition of the Phosphorus in Iron Alloys.*

Carbon per cent.	Phosphorus per cent.		
	Free as Fe_3P	In solution.	Total.
0.0	0.0	1.75	1.75
0.125	1.18	1.37	1.55
0.18	0.59	1.18	1.77
3.7	1.00	0.75	1.75
0.8	1.03	0.73	1.76
1.4	1.16	0.60	1.76
2.0	1.18	0.55	1.73
3.5	1.40	0.31	1.71

Position-of-Eutectic Experiments.

To illustrate further the structure of cast iron, the Author carried out some tests to determine the actual position of the constituents after complete cooling down had taken place.

The tests were made on an approximate sphere of 2 in. diameter and successive layers of metal 1/16-in. thick were taken from off the outside until the centre core was reached.

In order to show more clearly the effect on this comparatively small test piece, it was cast in a chill mould, so that the rate of cooling on the outside would be rapid, whilst that at the centre, by removing the chill almost immediately after pouring, would be slower, thus giving conditions approximating to a heavier casting. The results, together with a record of the hardness in Brinell numbers are shown in Fig. 3. It will be seen that the phosphorus content given in terms of the element itself reached the figure of 1.15 per cent. in the centre, whilst it was only 0.97 per cent. towards the skin. The comparatively sharp rise immediately under the skin was due to the annealing of the test-piece for machining purposes which caused a migration of eutectic outwards due to the internal pressure produced in the casting as cast in the permanent iron mould. This pressure, thus given freedom of action by the annealing process, was so intense as to force some of the phosphide eutectic right through the skin, where

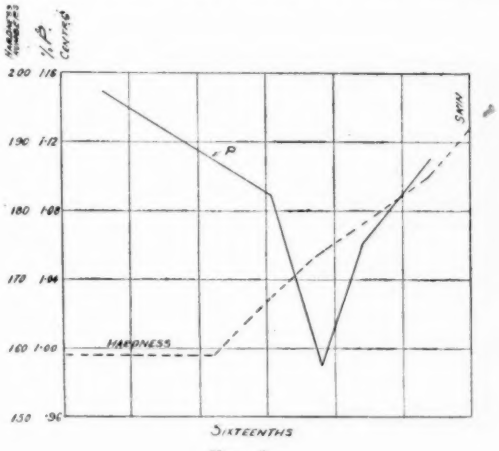

FIG. 3.

it emerged from between the crystals and formed pellets on the outside of the casting. The effect of the annealing is also seen in the total carbon content at the skin, where slight oxidising conditions had decarburised the material.

A further test to determine the weakening effect of the phosphide eutectic was carried out on specimens taken from the further samples of spheres, as above, and designed for compression tests. The size of these test-pieces was 0.3183 in. dia. (one quarter in. sq.), and two diameters high, two being taken out of the side of the casting close to the skin, but clear of chilling effect, and two from the centre of the casting. A load of 40 tons was applied in each case, and the reduction in height measured. Table III gives the results on both sand-cast and permanent-mould cast samples, the reduction in height being shown as a percentage on the original height.

TABLE III.—*The Effect of Phosphide Eutectic on Compression Tests.*

	Sample taken from side of casting.	Sample taken from centre of casting.
Sand Cast ..	6.0% 6.4%	10.1% 9.0%
Chill Cast ..	5.2% 5.0%	6.4% 6.6%

Disposition of Silicide of Iron.

The disposition of the silicide of iron in a casting is also noted in Fig 4. Silicide of iron has the property of precipitating the graphite from its union with the iron, and since the lower density graphite occupies more space than the same carbon in combination, shrinkage and strains are reduced, producing sounder and stronger castings up to the point of the graphite precipitation being so great as to weaken the structure by undue separation of the crystal grains.

The element which has received the most attention from investigators of cast iron is carbon. This is rightly so, if only on account of the fact that the effects on most of the other components are produced indirectly through the carbon. Also the condition of the carbon compounds in cast iron is more than anything else responsible for the change of properties which may be brought about

* Iron and Steel Inst., 1900.

in cast iron, either mechanically, electrically or magnetically. In this it influences cast iron in precisely the same way as steel and a study of the properties of the various carbon compounds in steel direct one's investigation of cast iron at once along the right channels. In thus considering steel first, the hampering or partial masking effects of "foreign" components are reduced and conclusions closer to the truth can be arrived at.

Iron exists in several different allotropic forms accurately determined by the differences of temperature, and these limits are again influenced by the presence of "foreign" elements.

These changes can all be noted by careful observation of the cooling curve, and are usually more accurately determined by the differences of temperature method where the temperatures are read relative to that of a standard pure metal, usually platinum, cooling down under exactly the same conditions.

As mentioned when discussing cooling curves, certain of these change points, as they are sometimes called, occur at several temperatures, and certain of these points correspond to changes into various allotropic forms of iron. For simplicity the number of such allotropic forms are usually limited to three, gamma iron, above 900 deg. C., beta iron, between 780 deg. C. and 900 deg. C., and alpha iron, below 780 deg. C.

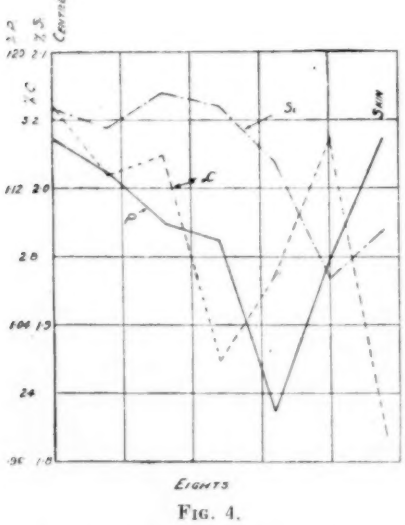

Fig. 4.

The various allotropic forms of iron also have differing magnetic and electrical properties along with mechanical differences, and it is the retention of the iron in any one of these states which constitutes the problem of producing steel with the particular properties sought. Of the three forms mentioned, the gamma variety is non-magnetic but, as seen, this property is lost when cooling below 900 deg. C. has taken place.

These temperatures, at which such profound changes take place, are greatly influenced by the presence of "impurities" or other elements, for example, an increase of carbon in pure iron up to 0.35 per cent. has been found to reduce the temperature at which the change from non-magnetic to the magnetic state occurs, to 760 deg. C.

This will give some idea of the extent to which these change points may be varied in a cast iron, where there may be as much as 0.8 per cent. combined carbon (the graphite not, of course, having any effect), as well as the other constituents usually present in cast iron. If the temperature at which the change from the non-magnetic to the magnetic state takes place can be further lowered, we may arrive at a point when this occurs at a temperature even below ordinary atmospheric temperatures.

The various iron compounds in cast iron, like those in steel, retain their general characteristics and properties when other elements are added, but the limiting temperatures of their existence may be greatly altered by those new elements. Osmond, Guertler and others have shown by their equilibrium diagrams that in a steel the critical change temperature from the non-magnetic to the magnetic state is lowered to about 200 deg. C. when the nickel content is raised to about 30 per cent., whilst under conditions of slow cooling both austenite and martensite may exist, both containing nickel in solid solution.

They found also that manganese acts somewhat similarly, but with about double the effect per

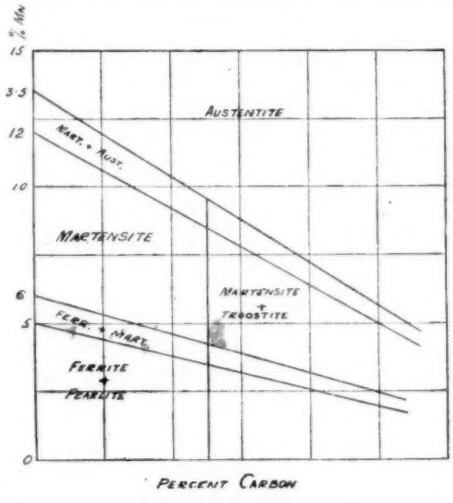

Fig. 5.—Structural Diagram for Manganese Steels.

per cent. present. Chromium forms austenite or martensite with cementite, the carbide being very hard, whilst tungsten and molybdenum produce martensite and mixed cementites of carbide of iron and their own carbides.

The structural diagram by Guillet (Fig. 5)* shows the effect of manganese on carbon steels up to 1 per cent. carbon, whilst Fig. 6† shows his diagram for nickel.

All these considerations indicate that in order to produce a non-magnetic cast iron it is necessary to select as addition elements, those which prevent or retard the change point to the greatest degree and also this effect will be very much different and perhaps more intense in the case of cast iron due to the effect of "impurities."

If we consider, for example, the addition of nickel to steel we note from Fig. 6 that about

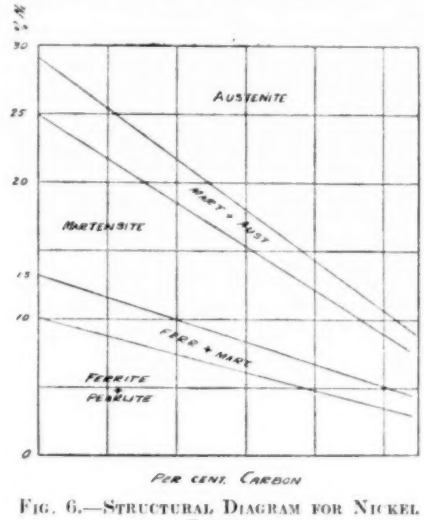

Fig. 6.—Structural Diagram for Nickel Steels.

25 per cent. would be required to produce the austenitic condition for low carbon steels, and from Fig. 5 that about 12 per cent. of manganese is required to have the same effect.

We should expect then in combination, that the effect would be produced by percentages which would total up to the equivalent of 25 per cent. nickel.

* Gulliver, p. 325.
† Gulliver, p. 323.

The position is somewhat obscure in the case of cast iron, but that the complete change can be brought about is evidenced by the various non-magnetic castings shown in the illustrations.

In this material the change point has been so effectively lowered that on subjecting it to the temperature of liquid air only a slight degree of magnetic permeability is obtained.

To determine now the extent to which the electrical and magnetic properties of cast iron might be turned to account the essential facts relating to magnetism as applied in the electrical industry must be considered.

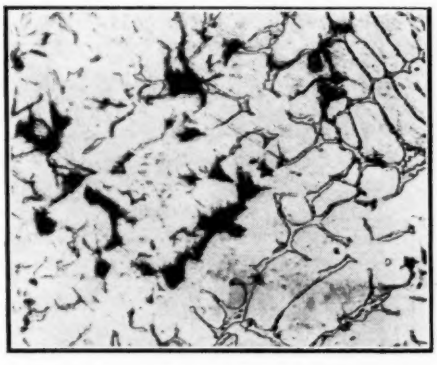

FIG. 7.—STRUCTURE OF NON-MAGNETIC CAST IRON SHOWING AUSTENITIC AREA × 220.

It is well known that an electric current flowing in a conductor produces a magnetic force or field in the surrounding space. For practical and calculating purposes this force is represented by lines known as magnetic flux lines drawn in the direction of the force. This direction is at right-angles to the flow of current. The density of these lines indicates the strength of the magnetic field. Such flux lines form in all materials and substances, including air, but some materials offer much greater resistance to the lines than others—that is, their magnetic conductivity is less. This conductivity for any material is expressed by comparison with the magnetic conductivity of air. The ratio of the conductivity of the material to that of air is known as the permeability of that material. The permeability of air is taken as unity.

The permeability of cast iron, for example, is approximately 330, so that for a given current or magnetising force the magnetic field will be 330 times as strong in cast iron as in air. If a non-magnetic material such as brass, tin, wood or non-magnetic cast iron be placed in a magnetic field, the density and direction of the flux lines will be unaltered, as it would through air, but if a piece of iron or steel be substituted, the strength of the field will be increased by an amount depending on the permeability of that material.

By one of the fundamental electrical laws, a changing magnetic field produces an electric-motive force (E.M.F.) or electrical pressure. If the flux lines pass through a material which is an electrical conductor, the E.M.F. so produced will set up circulating currents depending on the resistance of the material in accordance with ohms law. These are known as eddy currents, and they cause a watts power loss in the material which is dissipated in the form of heat. This loss will depend on the electrical resistance of the material and the strength of the magnetic field, and hence on the permeability, and may seriously affect the efficiency of electrical machinery, giving rise to excessive heating with consequent loss of energy.

If the varying flux lines pass through a magnetic material (that is, permeability greater than 1), a certain amount of energy is required to change the direction of the lines. This energy loss is known as hysterisis loss, and exists in addition to the eddy current loss just described.

Electrical generators, motors, transformers, and all electro-magnetic machinery depend for their operation on the production of the magnetic field. So far as possible this magnetic field is controlled, and the flux lines are confined to the desired paths, but since there is no magnetic insulator or material opaque to a magnetic field (that is, no materials have a permeability of zero), it is not possible to do this completely. For this reason, and also because magnetic flux lines surround every conductor carrying current, there will be magnetic fields not only in the paths desired and provided, but also in the neighbouring places. Such magnetic fields are usually known as stray or leakage fields. The eddy current and hysterisis losses due to these fields

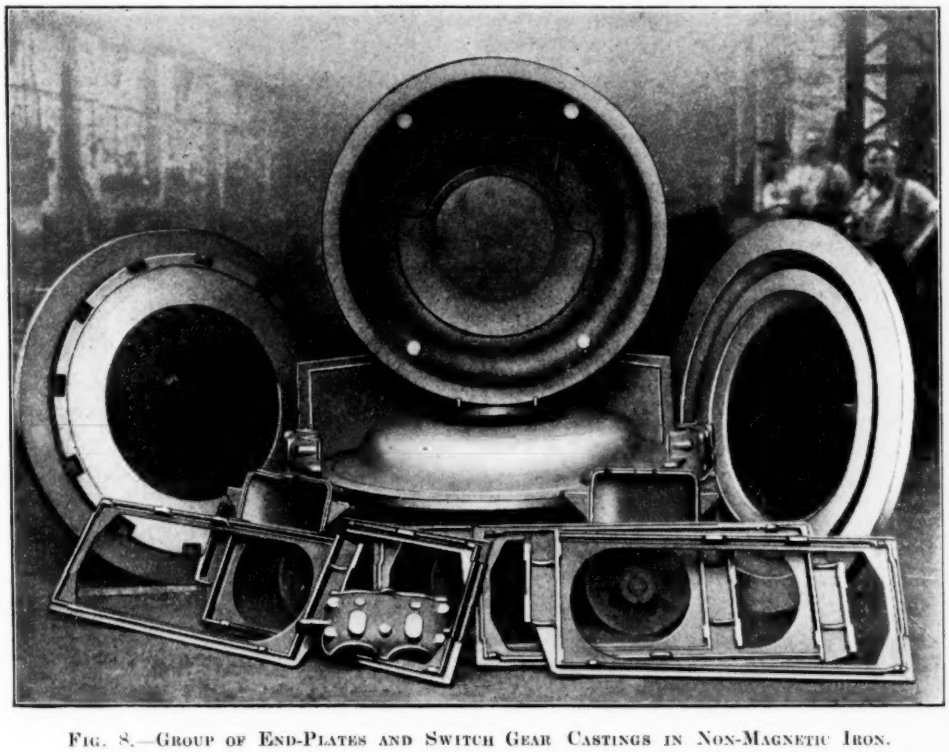

FIG. 8.—GROUP OF END-PLATES AND SWITCH GEAR CASTINGS IN NON-MAGNETIC IRON.

decrease the efficiency, and frequently cause excessive heating in electrical machines of all kinds.

We thus see that non-magnetic iron with its unity permeability and high resistance gives a combination of properties which does not exist in any other metal or material, and is most useful in the manufacture of cable bushes, switch covers, busbar clamps, sealing bells, terminal supports, generator and motor end plates, insulator carriers and holders, etc.

These characteristics of non-magnetic cast iron are clearly seen in Table IV, shown in comparison with ordinary grey cast iron and brass.

TABLE IV.—*The Magnetic Characteristics of Cast Iron, "Nomag," and Brass.*

	Magnetic Permeability Maximum.	Specific Resistance. Micro-ohms. per cm. cube.
Ordinary cast-iron	330.00	95.0
"Nomag" ..	1.03	140.0
Brass	1.00	7.5

Its high resistance also makes it admirably suitable for resistance grids, and its toughness, as shown by the Izod test* (which is 29 ft.-lbs. as compared with 14 ft.-lbs. for ordinary cast iron†), gives a grid capable of withstanding mechanical shocks which it may receive in service and in handling to a remarkable degree.

These grids are used for various purposes in electrical engineering, chiefly as a means of regulating current values and for starting and controlling the speed of motors. For all kinds of traction work, railway, tramway and crane motors, etc., where starting, stopping, and speed variation is a frequent occurrence, resistance grids play an important part in electrical control. For this class of work the grids, in addition to having high resistance, must be very strong mechanically to withstand rough usage. The electrical resistance should not vary with the temperature—that is, the resistance temperature coefficient should be small.

In addition to its mechanical advantages, non-magnetic cast iron combines high resistance with low temperature coefficient to an exceptional degree. The resistance temperature coefficient

FIG. 9.—ALTERNATOR END RING IN NON-MAGNETIC CAST IRON. IT WEIGHS 3 TONS 12 CWT.

for "Nomag," for example, is 0.09 per cent. per deg. C., as compared with 0.19 per cent. per deg. C. for ordinary cast iron.

Such grids made in non-magnetic cast iron of high electrical resistance are now in use in most of our principal tramway systems, and since their extra 40 per cent. resistance allows of (a) less grids being used, (b) thicker sections being employed, and (c) shorter paths between terminals, they result in a better air circulation, with consequently better removal of the heat produced, or a more robust grid.

An actual service test on such grids carried out at one of our most important and hilly tramway undertakings showed that, as already stated, the resistance did not increase with temperature to the same extent as ordinary cast iron grids did; in fact, after running the car on the resistance notch for long periods until the boxes were hot, no appreciable difference could be detected when feeding up on the controller. This is especially useful when a large number of stops have to be made, when bad acceleration is usually experienced due to the varying resistance.

As regards the effect on magnetic property of

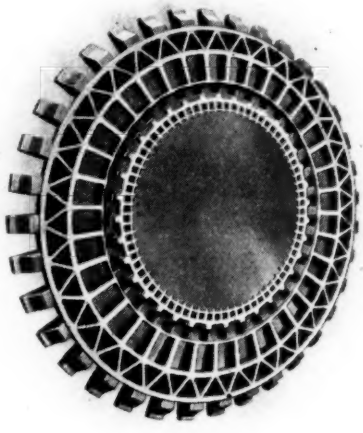

FIG. 10.—ALTERNATOR END RING IN NON-MAGNETIC CAST IRON. ITS DIA. IS 5 FT. 6 INS.

the so-called "impurities" in cast iron, Goltze says that combined carbon and manganese tend to decrease the permeability, although both silicon and manganese tend to increase the resistance. Nathusius in 1905 carried out a number of tests on a series of cast iron with varying combined carbon content, and found that the low combined carbon and high silicon raised the permeability. His figures were:—

	C.C.	C. Gr.	Si.	Induction at ampere turns per cm. 25	50	100	200
1.	.. 0.24	3.19	2.83	7,100	9,200	11,200	12,900
2.	.. 0.82	2.47	2.11	5,900	7,500	9,200	11,300

Although the above figures do not indicate directly the permeability, yet the induction figures shown are proportional to permeability, and in the absence of a constant not indicated by Goltze, they do not represent absolute permeability, but they indicate on plotting that the higher combined carbon cast iron has regularly lower permeability for each of the currents indicated. Goltze also states that phosphorus and sulphur have no influence on this factor.

The coefficient of expansion of non-magnetic cast iron is somewhat higher than ordinary cast iron, and more nearly corresponds to that of mild steel. The relative figures on a given size of test-piece are shown in Table V.

TABLE V.—*Coefficient of Expansion of Various Alloys.*

Ordinary cast-iron	$9.6 \times 10-6$ per 0° C.
Mild steel	$11.0 \times 10-6$ per 0° C.
Brass	$23.3 \times 10-6$ per 0° C.
Non-magnetic cast-iron	$11.9 \times 10-6$ per 0° C.

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* Taken on Test Bar. 20 m.m. × 20 m.m. × 70 m.m.
† Silicon 1.8%; phosphorus 0.46%; tensile 14.9 tons per sq.in.

Moulding Sands for Steel Castings.*

By A. Rhydderch, B.Sc., M.I.Brit.F.

The data which will be presented in this Paper refers to moulding sands that are used in the making of steel castings of light, medium, and heavy sections. Naturally, many of the principles discussed will be applicable in various degrees to all ferrous and non-ferrous moulding sands.

Refractoriness.

The question of refractoriness is first and foremost in the selection of any suitable facing sand for medium and heavy work to be used in a steel foundry. To realise this the conditions under which these sands are used can be profitably studied.

Table I shows the melting point of medium and low carbon steels, and also that of manganese steel.

TABLE I.—*Steel Foundry Temperature Data.*

0.1% carbon steel melts about	1490° C.
0.3% " " " "	1460° C.
Manganese " " "	1350° C.
(C 1.2%. Mn. 12%.)	

CASTING TEMPERATURES.

For Mild and Medium Carbon Steels.

Less than ⅜ in. section	1580—1640° C.
Between ⅜ in. and 2 in.	1530—1580° C.
Over 2 in.	1500—1550° C.

These results are the average of many determinations, and were taken with an optical pyrometer, the observed figures being corrected to true readings assuming Burgess' emissivity correction.

It will be noticed that the highest temperature a facing sand has to stand is in the neighbourhood of 1650 deg. C., whereas the lowest, except in the case of some alloy steel, is about 1490 deg. C. Of course, the casting temperature depends on the steel used to a very great extent, a dead-mild steel requiring a higher pouring temperature than a high-carbon or a high-manganese steel, such as Hadfield's "Era" manganese steel. This is governed by the degree of fluidity at a particular temperature, so as to enable the steel to fill the mould without cold lapping. Generally speaking, this fluidity is directly connected with the amount of super-heat above the melting point of the steel in question, although various other factors also affect the fluidity of steels. For example, nickel-chrome steels and silicon steels are very sluggish even at temperatures well above their melting point, whereas manganese steel is very fluid at 1450 deg. C.

From the above it will be seen that the refractoriness is of prime importance in the selection of facing sands for use in steel castings.

Raw Materials for Moulds.

The material used in the making of moulds for steel castings can be divided into 3 groups of 3 divisions: First of all there are the naturally-bonded sands, *i.e.*, sands which carry their own bond and have sufficient cohesiveness to be used without the addition of any external binder, as, for example, the Belgian and Cornish sands and some of the Bunter sands, such as Worksop.

Then there are the synthetic sands or the artificially-bonded sands, which are simply made by mixing a suitably-graded high-silica sand with a refractory fireclay.

Thirdly, there is what is commonly known as "Compo," which is used on the heavy-sectioned castings. These are generally made up of mixtures of ganister, well-burnt fireclay pots, retort bricks, bonded with fireclay, and their chief difference when compared with the true melting sands is a question of grain size. Some of the coarser "Compos" are comparable with gravel.

Naturally-Bonded Sand.

On analysis, naturally-bonded moulding sands are found to be composed of grains of silica covered with a thin layer of bond, part of which is of a ferruginous nature and part of which is of an aluminous nature. The mineral analysis of these sands reveals the fact that there are present free silica, feld spars, micas, hydrated iron-oxides, and clay, and numerous other minerals in very small quantities.

Unfortunately, these mineral intruders have a very low melting-point when compared with that of silica, and will, therefore, have a very detrimental effect on the fusion of a melting sand.

When a moulding sand is mixed with some water and shaken vigorously, then allowed to settle, it will be noticed that the sand will separate out into three or more distinct layers. The bottom layer, on analysis, proves to be nearly pure silica, and the intermediate layers gradually become lower and lower in silica until the fine, flocculated matter contains anywhere between 40 to 55 per cent. of silica.

From this it will be seen that the impurities in a moulding sand are invariably found in the very finest grade, which is termed the "clay-grade" according to Professor Boswell's definition.

Examination of Clay Grades.

Table II shows a series of analyses on the clay-grades of various moulding sands. These clay-grades were obtained by the process of elutriation of these sands, as detailed in Professor Boswell's "Memoir on Refractory Sands."

TABLE II.—*Chemical Analysis of Clay Grades of Some Natural Sands.*

Name of sand.	Silica. Per cent.	Alumina Per cent.	Iron oxides. Per cent.	Alkalies.	Loss on ignition.
French red	44.04	28.06	12.84	0.47	11.94
Worksop yellow	53.02	28.36	5.00	1.42	9.54
Worksop red ..	53.62	25.59	6.86	2.58	8.70
South Cave red	36.16	22.36	22.80	1.14	14.38
South Cave yellow	43.98	33.45	14.95	1.67	11.76
Hutton Ambo middle seam.	52.62	24.52	7.04	2.03	11.16
Belgian yellow	55.46	22.22	9.04	0.90	9.20

It will be noted that the silica in all cases is very low; the alumina varies from 22 to 29 per cent., the iron-oxide from 5 to 22.8 per cent., the alkalies from 0.9 to 2.58 per cent., and the loss on ignition from 8.7 to 14.38 per cent.

TABLE III.—*Analysis of Cornish Red Sand, Showing Variation with Grain Size.*

	Bulk Analysis.	F.S. mm. > .25 < .10	C.S. mm. > .10 < .05	f.s. mm. > .05 < .01	C. mm. > .01
SiO_2 ..	83.89	96.73	92.07	55.34	46.67
Al_2O_3 ..	5.38	1.04	3.02	18.87	20.78
Fe_2O_3 ..	2.31	} .05	1.25	9.85	12.89
FeO ..	0.18	}	0.20	0.47	0.41
MnO ..	0.58	0.013	0.17	1.27	1.52
CaO ..	0.48	0.26	0.38	0.95	2.27
Na_2O ..	0.04	0.08	0.09	0.18	0.40
K_2O ..	2.20	0.38	0.89	2.02	2.29
TiO_2 ..	—	0.14	0.42	0.85	0.85
Loss ..	0.48	0.63	1.21	10.14	12.29

From Prof. Boswell's Memoir.

This shows very clearly how the impurities and less refractory minerals are found in the finer grades.

It will be noted that, generally speaking, the high loss of ignition has a rough relation to the amount of iron-oxide present, thereby indicating the presence of hydrated iron-oxides.

* A Paper presented to the London and Sheffield Branch of the Institute of British Foundrymen.

Now this fine material, which is flocculated in the test tube and the analysis of which is typical of what has been shown, exists in the sand chiefly as a coating of the silica grains. In other words, this is the part that gives the sand its cohesiveness or binding properties.

Table III shows the series of analysis on an elutriated moulding sand, and bears out the statement previously made that the silica content gradually gets less as grade becomes finer, and the impurities simultaneously increase.

To test the point for refractoriness of the bond, a few experiments were made to determine the fusion points of the bonds obtained from well-known foundry sands. The results obtained are shown in Table IV.

Table IV.—*Fusion Point Test.*

Sand.	Grade.	Sintering temp.	Squatting temp.	Remarks.
Belgian red	Sand	1520° C.	1640° C.	
	Clay	1480° C.	1540° C.	Probably on the high side.
Worksop red ..	Sand	1560° C.	1640° C.	—
	Clay	1340° C.	1520° C.	—
French red	Sand	1440° C.	1575° C.	—
	Clay	1380° C.	1465° C.	—
Mansfield red ..	Sand	1500° C.	1620° C.	—
	Clay	1240° C.	1300° C./ 1320° C.	—

(i) Rate of heating was 10° C. per minute; (ii) The sand grade was all passed through 80 mesh; (iii) Clay grade obtained by sedimentation, and (iv) Atmosphere reducing.

It will be noted that in some cases the first signs of fusion of the point were found at a very low temperature, whereas in Belgian sands the bond was almost as refractory as the moulding sand itself. What does this mean? It simply shows how important it is to examine separately the bond of these naturally-bonded melting sands, as apart from a pure melting-point determination. Because even as low as 1280 deg. C. Mansfield sand shows signs of fusion, and this will result in a reaction on the silica grains, producing a fused-mass for which the fettling shop will have to pay heavily when the castings arrive there.

These remarks apply to the medium-sized steel castings that are made in naturally-bonded moulding sands. In dealing with very thin-sectioned castings, generally cast in green sand, the question of refractoriness is probably not nearly of such vital importance, because the cooling is so extremely rapid that there is not much heat to be dissipated, and moulding sand may not even reach within a hundred degrees of the temperature of casting.

Another point is that nearly all naturally-bonded sands seem to form a very thin slag-skin which, under these conditions, seems to adhere to the sand and leaves the face of the steel perfectly clean except at the bottom of a mould, when it is generally fused to the casting. Analysis of this slag-skin shows that it is chiefly a ferrous-silicate. In manganese steel there is a very similar effect with any silica-sand, bonded with clay, resulting in the light manganese castings leaving the sand perfectly clean, free from any adhering patches of sand. The slag surface is always a complex iron-manganese silicate. As mentioned once before, it would be interesting to try to produce this stripping effect artificially by painting the face of the mould with a paint made up of a manganese salt, or oxide; but although this is the case with the smaller-sectioned castings in manganese, disastrous results are obtained with the heavier-sectioned castings, owing to the abundant formation of slag which will be found bedded in the face of the casting and other material must be used.

Stripping Properties of Sands.

By using a suitable mixture of semi-refractory bond and silica sand, a good skin can be obtained on light- and medium-steel castings, but it is essential that a good sand-cleaning process be used, otherwise the flow sand will gradually be tending towards a concentrated slag heap.

Unfortunately the question of why a sand should strip well is very difficult to explain. However, it is known that those naturally-bonded sands with an iron bond are far superior in stripping properties to synthetic sands with a fireclay bond. Even then, improper preparation of sands, such as insufficient milling, incorrect amount of water, can make a very large difference to the stripping qualities of a sand.

Again, some sands which do not strip at all when moulded green sand, behave quite well when used as dry sand. This seems to bear out the fact that the question of heat conductivity, or perhaps convection due to increased permeability, is a factor of some importance.

But that conductivity or permeability is not the deciding factor is well known; in fact, the most open sand the author has known was an exceptionally bad "stripper."

All that can be said is that the question of skin depends on the formation of a layer of slag which adheres to the sand in preference to the steel, and furthermore, that this action is favoured by the presence of hydrated oxides of iron—such as is found in the red and yellow sands—or by the presence of a manganese oxide.

It will be noticed that no mention has been made of the determination of the actual mineral contents of these sands. The reason being that it is extremely difficult to determine rapidly the minerals or the quantity of minerals in the finer grades where they most abound, although some recent papers have appeared of French origin wherein the authors claim that they have been able to predict accurately the behaviour of firebricks in practice. At present the easiest means to determine the behaviour of these sands is by a simple fusion-point test.

There is one other point before leaving the question of refractoriness, and that is whether the tests should be carried out in a reducing or oxidising atmosphere. Some experiments made by the author seem to indicate that there is a strong reducing action going on at the face of the mould.

Synthetically-Bonded Sands.

Synthetic sands are generally made up of very pure silica sand and a fireclay, the aim being to distribute the fireclay over grains of the sand, thereby imitating the conditions obtaining in naturally-bonded sands. Obviously, refractory fireclay must be chosen for this purpose.

"Compos."

A great deal of secrecy has been, and is being, observed about the ingredients in various "compos," and it is freely claimed that the success or failure of many a foundry is due solely to the mixings used on the larger-sectioned steel castings. Very little information is available, but it is found in Longmuir and McWilliam that they are generally made up of mixtures of crushed silica rock or ganister, firebrick and retorts, used fireclay crucibles, all bonded with clay or kaolin. Generally speaking, this is universal practice in Great Britain. In America there are no such things as "compos." All their large steel castings are made in moulds made of coarse-grained silica sands bonded with clay. In Germany they use something very similar to British compos, but there they use "chamotte," which is simply a hard-burnt fireclay bonded with the raw clay. This occasionally being diluted with small amounts of silica. The greatest difference between compos and moulding sands is the grain size.

Obviously the difficulty in preparing compos of such a composite nature is very great, and a very large amount of dust or silt is formed. They are generally prepared by using perforated pans and then grading very roughly the product. It is well established that grain-size materially affects the fusion point of any composite refractory material, this being quite apart from any change in the chemical composition, which it is assumed remains the same. In some cases it can even affect the refractory property by as much as 20 deg. C. The coarser-grained material having, generally speaking, the much higher fusion point. Why is it that "compo" is used on all large castings? It is difficult to find a reason, except for the fact that a mixture of silica and fireclay can be so arranged that there is no permanent expansion or contraction on drying the moulds. The reason being that silica has a permanent expansion and fireclay a permanent contraction. It should be stated here

that "compo" moulds are generally dried anywhere between 400 and 600 deg. C., and at 575 deg. C. there is a considerable change in the volume of the silica. This implies that on drying the moulds may be liable to crack. Another reason is given that burnt fireclay breaks down in angular fragments without powdering, whereas silica sands fall to powder. This certainly has not been the author's experience, and he cannot bear out this statement. In fact, the very nature of silica results in angular fragments on casting.

Increased refractory properties due to increased grain size is a very essential attribute when one considers what a mould, made for a very large, heavy steel casting, has to stand. Very often one finds the section of a casting as much as 20 to 30 in. in diameter.

Pressure and Refractoriness.

During fettling one always notices that the bottom part of the casting is invariably more difficult and more costly to fettle than the top part. Why is this? In a paper by Bradshaw and Emery there is some very valuable information showing the effect of load on the question of refractoriness of a mixture of fireclay brick and silica brick. Fig. 1 shows the results obtained.

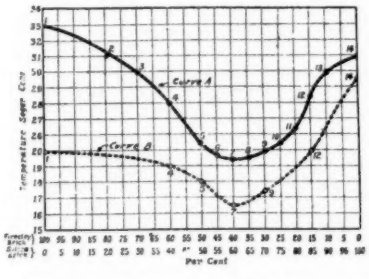

FIG. 1.—INFLUENCE OF LOAD ON A MIXTURE OF FIREBRICK AND SILICA BRICK.

It will be noted that their mixture of fireclay brick and silica brick, when mixed in certain proportions, lowers the fusion point to cone 19, and that under load of 25 lbs. per sq. in. this is reduced to cone 16 or 17. Further, those high in firebrick show much greater difference between fusion tests with and without load. Here is an explanation of why the bottom of the mould sticks to the casting. At the bottom of any deep mould there is a considerable ferro-static pressure, very often as great as 25 lbs. per sq. in., so that the actual fusion-point of the material in the region is very much lower than what it is at part of the casting near the head. But here again, as in the naturally-bonded sand, much depends on the refractoriness of the bond itself, which coats the grains to give it the necessary cohesiveness, and in this case a more detailed examination of this finer-grade often explains the failure of various compos.

From the above it will be clear that in using compo it is better to dilute the silica with fireclay to counteract contraction cracks in the mould than to work at the fireclay end of the mixture. It is realised that in making this statement the author is practically damning the modern Sheffield practice. America and Germany work at the extreme ends of the scale of the diagram, whereas Britain works at the middle and suffers accordingly. How often does one find that a chipping or fettling cost for one particular type of casting might vary anywhere between £5 to £15 per casting, due to the fact that such complex mixtures are so difficult to control. This is probably accentuated by a big variation of grain size which cannot be avoided in the production of such "compos." It would be interesting to know the origin of the use of "compo." The author believes that the behaviour of these complex "compos" is too variable to be of use in any progressive foundry.

Mechanical Strength and Permeability.

To determine permeability to gases and strength or cohesiveness, it is essential that there must be some method of testing which will give comparative figures which are reliable to a moderate degree of accuracy. These figures need not be of absolute dimensions, as long as some standard on which to work is determined. When the author first took an active interest in the subject of sand testing about six years ago, very little information could be found dealing with this subject. Numerous articles spoke very loosely of open sands and strong sands, but seldom, if at all, were any tests indicated whereby quantitative results could be obtained. And after all, it is only when foundrymen receive quantitative results that they can hope to investigate thoroughly the problem and to make any progress towards the production of more permeable sands. After numerous experiments, it was decided to use a method of ramming to a fixed density with a fixed percentage of water. The bars were then tested in compression in a modified cement testing machine, or by pushing the bar over the edge of the plate, termed the transverse method, or by breaking a bar supported at both ends with a load at the centre. Some of the results obtained by these methods have been quoted in Professor Boswell's book on British and American foundry practice, and were made when the author was a member of Messrs. Hadfield's Research and Technical Laboratory. It was realised, however, that this method was open to several objections for comparing sands from various sources and of varying grain-size and bond, though it served admirably for controlling the variation in one particular sand from day to day.

Controlling Variables.

In a large foundry that is the first essential, to fix as many varieties as possible, then the diagnosis of troubles becomes an easier matter. The permeability, or rather the impermeability, tests were made by ramming a 1-in. tube to give 2-in. lengths of sand. Altogether each tube was filled with five 2-in. lengths of sand, making 10 in. in all. Then forcing through the sand a definite quantity of air, noting the time taken and also the steady pressure set up. The back pressure is very important, because when the steady pressure becomes greater than that of the steel, the air will go through the steel instead of the sand. Of course, it is immaterial which standard one takes for a standard of reference. It was soon discovered that the transverse test was most easily handled and gave the most consistent results, generally within 10 to 15 per cent., which was considered satisfactory at that time. A large number of tests were carried out on each batch of sand and a grand average taken. It was always noticed, however, that the results always tended to steadily decrease or increase if a few hours were taken in the testing, and it was also noted that much more force was required to ram some sands than others. The progressive increase or decrease was put down to the drying of the sands with use, the used bars being mixed with the unused, which were kept in a humidor.

TABLE V.—*Effect of Amount of Moisture on Strength.*

The first	15 bars tested gave			200 grms.,		moisture	6.9%
second	15	..	..	.. 215	..	..	6.7%
third	15	..	..	.. 225	..	..	6.6%
fourth	15	..	..	.. 230	..	..	6.4%

This shows how important it is in testing any sand, under whatever method is adopted, to keep the water constant. The same, of course, applies to the sands prepared for actual use in the foundry.

Regarding the different force required to ram the various sands, that depended on the clay contents and the water present. It depended most of all on the nature of the clay present. Those clays that showed the greatest tendency to swell were generally the hardest to ram. In practice, it can be stated that the moulder rams on one particular job with a fairly constant pressure and does not vary the strength of his ramming to suit the sand. In order, therefore, to compare sands under similar conditions of ramming, it became necessary to ram either with a fixed pressure or a fixed blow, and arrange the quantity of sand used, so that the resulting bars would be of approximately the same thickness. This is necessary because moulding sands will not obey the laws of elasticity, and it is therefore necessary to fix a suitable size. In

the author's case, he fixed 1 in. sq. as a size because of the previous tests which had been carried out on this basis. Therefore, as the sands became coarser, it is evident that a bigger cross-sectional area was required; certainly 1 in. would not do. In view of Doty's Paper, published in the A.F.A., 1922, it is extremely interesting to note that the same method of attack had been adopted, although Mr. Doty had refined the test very considerably, and it succeeded in repeating the results on the finer-grain sands to 5 per cent., which is excellent when one considers the nature of the material tested.

Standardisation of Testing Methods.

Since reading the paper of Doty's, the author has altered the apparatus and finds that the tests on fine sands used for light work certainly come easily within the 5 per cent. mark, though the medium and the coarser sands show greater errors. Of course, this can be understood by considering how a sand breaks. At the same convention, the American Foundrymen's Association put forward a method for testing permeability. This is very similar to the one used at Messrs. Hadfields, Limited, as can be seen from the description in Professor Boswell's book. The important point to bear in mind in connection with testing is that the members of the Institute of British Foundrymen must standardise these tests, so that they can discuss each other's troubles without indulging in a lot of vague platitudes. America, owing to her reliance on the synthetic sands, has been compelled to find a way. We in this country, with our unrivalled raw self-bonding sands, are satisfied, and one finds that all the papers published on the testing of sands are using different units. Certainly the results can be compared, but the operation is so tedious that it is seldom attempted. Why not publish in THE FOUNDRY TRADE JOURNAL and in the Institute proceedings the tests suggested by the A.F.A., to be brought up for discussion at the Newcastle Conference? We could then decide on our own standards and investigate on a quantitative basis the properties of our moulding sands. At any rate, the outcome of this is that by a series of comparative tests we are in a position to judge our various sands, compared with each other in strength and permeability.

TABLE VI.—*Effect of Density, or Hardness of Ramming on Strength and Permeability. Sand used—French Red. 5% Moisture.*

Density.	Transverse strength.		Compressive strength.	(Im)Permeability. in secs.
	Method "A"	Method "B"		
1.300	30	< 50	50	15
1.400	45	< 50	110	25
1.500	50	90	130	43
1.600	—	—	—	77
1.650	90	145	300	—
1.700	—	—	—	145
1.765	100	200	480	—
1.85	120	230	490	—

Similar information to this is required on every moulding. Those sands which show the lowest rate of increase in (im)permeability are obviously the more foolproof in use.

Having thus briefly mentioned the method of testing, a few results are given in Table VI showing the effects of moisture and density of ramming on the properties of moulding sands. Table VI shows the strength and permeability of French red sand with a 5 per cent. added moisture-content. It will be seen that the increase in impermeability is out of all proportion to the increase in strength at the higher densities.

Figs. 2 and 3 show these figures on a graph. The important point to note on this particular sand is that the ratio of strength to permeability has a maximum value in the region of 1.4 to 1.5 density for dry sand at 100 deg. C. In practice this sand was actually rammed to about 1.58 to 1.65 density, density.

Fig. 3 outlines a test on the strength of sand rammed in a similar manner, *i.e.*, rammed under the same pressure, gradually increasing water percentages.

Without giving any further illustrations, it can be said that every sand has an optimum water content at which it develops maximum strength. It can also be stated generally that it is better practice to use the least amount of water rather than aim at the optimum water content. From the above, it will be realised what a very important part density and moisture play in the strength and openness of moulding sands, and after all, each foundry aims at using the best and, at the same time, the cheaper sand to be found in the locality. It is, therefore, important that all the properties of the local sand should be known, and as many variables as possible fixed.

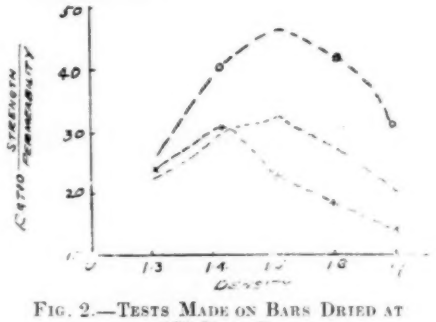

FIG. 2.—TESTS MADE ON BARS DRIED AT 100 DEG. C.

Why should the ratio of the strength over the permeability plotted against density show a maximum in the region of 1.4 to 1.5 for dried sand? If this holds good for all sands, then this value can be used as a criterion in judging sands suitable for foundry work.

The density of ramming is certainly difficult to control, because every moulder rams with a different pressure. The shapes of the patterns in machine work also results in parts of the mould being rammed at very different densities. This is so, whether the man uses a jar ramming or a squeezer, but the moisture content can be controlled, and it is certainly of great importance.

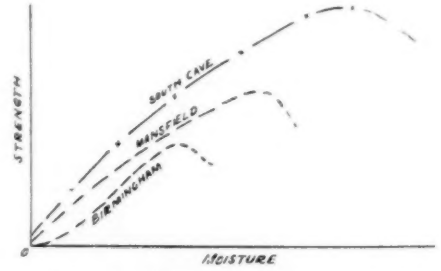

FIG. 3.—EFFECT OF MOISTURE ON STRENGTH.

It emphasises the necessity of specifying moisture content when speaking of strength.

It is also very important in selecting moulding sands to choose those that do not show a big variation in properties with small differences in ramming and moisture content. This is one reason why it is better policy to work with the sand on the dry side.

(To be continued.)

THE BRISBANE TRAMWAYS BOARD has accepted the tender of Dorman, Long & Company, Limited, for a further 1,500 tons of tram rails and fastenings. These will be manufactured in England for delivery on completion of the contract for 15,000 tons already placed.

THE GLASGOW CORPORATION, on May 15, discussed a recommendation of the Tramways Committee that an offer for track work by the United States Steel Products Company should be accepted. The company wrote that they guaranteed that the rates of wages, hours, and conditions of labour were equal, and in some cases better, than those ruling in similar works in the United Kingdom. It was moved that the lowest British offer, that of Edgar Allen & Company, Limited, Sheffield, be accepted, that tender being £500 higher than the American offer. The objections to the American offer were based chiefly on the ground that the working conditions were not equal to the British. On a vote, the contract was awarded to the Sheffield firm by a majority. The American tender amounted to £6,368, and Messrs. Edgar Allen & Company's offer £6,900.

Institute of British Foundrymen.

LONDON BRANCH

Visit to Chain Factory.

On Saturday, May 17, a visit was paid to the works of Messrs. Bagshawe & Company, Limited, of Dunstable, and the opportunity was taken of holding the annual general meeting of the Branch at the same time. There was a party of about 50, who were conducted round the works by Messrs. Bagshawe, Gardom and Pollock.

Although the firm would not claim that their works is a large one, yet it is a representative one for its particular purpose, which is mainly repetition work in malleable for chain-making. Other work is turned out, such, for instance, as conveyor buckets, but the art of the firm is chain making on repetition methods. These chains are for general purposes, such as agricultural and brewing machinery, and the many other purposes for which driving chains are used, as distinct from the type of chains used for bicycle driving and the like. Indeed, it is not uncommon for inquiries for this latter type of chain to be passed on to the makers who specialise in their manufacture, whilst, on the other hand, the makers of bicycle and similar chains pass on inquiries for agricultural and allied types of chains to Messrs. Bagshawe.

The works themselves are situated in Dunstable, on the road to Luton, and are extremely pleasantly situated. At first sight it almost seems that an old oak-beamed house had been acquired and converted for offices, but the fact is that it is a modern copy of such a type of house, and very attractive the main building looks with its grass in front.

Basis of Costing.

Coming to the more technical part, it may be said that the works have been laid out primarily for repetition malleable work, and it is interesting that the basis of production is to get the work through the foundry at so much per ton. The actual basis is £1 per man per day, and it can be imagined that in order to do that every conceivable non-essential has had to be cut out. Thus the works may be regarded as a splendid example of specialised and standardised operations almost on one class of product. All work is done on a piece-rate basis, and it is stated that an average of 95 per cent. efficiency is maintained.

Amongst the various departments visited, special interest was shown in the room where are hanging samples of every type of chain made by the firm. At first sight it certainly struck one that the number of similar patterns was very large, but very good reasons were given for that state of things. Included in these chains were some samples of American and German chains, and no excuse need be offered for noting the opinion of the firm that some of the American chains are by no means good ones, whilst the German chains are almost invariably found to be extremely good and suitable for the purpose for which they were intended.

There is quite a large machine shop attached to the foundry, because the firm manufacture the chains from start to finish, and it has been found preferable to do a considerable amount of drilling rather than to adopt coring. Again, it has been found better to weather the ore by leaving it in the open for two or three weeks rather than to attempt to achieve the same object by watering it and keeping it under cover.

Annealing.

Five annealing ovens were working at the time of the visit, and they are all coal-fired. Messrs. Bagshawe have found this better, in the case of malleable, than gas, but the opinion is held that pulverised fuel will give even better results, and that it will eventually be adopted. In the meantime, experiments are being carried out with modified forms of firing, and although better results are being obtained, information of a more definite character will be available in a few months' time.

These are a few general notes appertaining to the visit, and are not intended, obviously, to serve as a description of the works, but merely to indicate the type of product and the principle upon which the works are laid out and run. There is a gas producer plant which generates the electricity for lighting and power. Every department was visited in turn, and the visitors came away feeling they had spent a pleasant and profitable afternoon.

At the conclusion of the round of the works the annual general meeting of the Branch was held in the offices.

ANNUAL GENERAL MEETING.

THE BRANCH-PRESIDENT (Mr. V. C. Faulkner), in opening the Annual General Meeting of the Branch, said that during the past year a regulation had been formulated by the General Council which necessitated holding the Annual General Meeting in the month of May instead of in September, as was the practice with many of the Branches, and it was therefore thought that advantage might be taken of this visit to hold the Annual General Meeting. In London, owing to the vast distribution of the Branch, it was almost impossible to get a representative meeting at any time, and the Council thought that as representative a meeting would be obtained on the occasion of this visit as by calling a meeting in London. Before vacating the chair the President sincerely thanked the officers of the Branch for their support, and especially mentioned Mr. Shaw and Mr. Sommerfield, who had really taken on the work of the Branch. He also expressed, on behalf of the Branch, thanks to Mr. Hand, who so kindly took charge of the lantern at the various meetings of the Branch.

THE SECRETARY (Mr. H. G. Sommerfield) then read his annual report as follows, but before doing so said that although Mr. Faulkner had been kind enough to speak of the help given him by other members of the Council, Mr. Faulkner was really the mainstay of the London Branch, and a great deal of the work fell upon his shoulders :—

"I have pleasure in submitting to you my report of the London Branch for the Session 1923-24.

"The Membership Register has recently been carefully considered by the Council with a view to it being shorn of those names of members whose connection with the Branch has ceased for various reasons. To-day, after its revision, membership of all grades stands at 176. During the past year 21 new members have been nominated by your Council and elected by the General Council for membership. Three members, on account of removal, have been transferred to other Branches, and twelve names have been deleted from the Branch Register by reason of resignation, no trace of address, arrears of subscription, etc. I also regretfully have to report the death of four of our members during the session—Messrs. Sutherland, Pearce, Morehead and Lawler.

"Every effort has been made to provide the most instructive and interesting lectures for our meetings, and in addition to gentlemen from other Branches, some exceptionally good lectures have been contributed by our own members. Attendance has maintained a fair average, and one or two have been really large meetings. The Saturday afternoon meetings have not been quite so popular as the week-night ones.

"In addition to monthly meetings of lectures and discussions, visits were arranged to the works of Messrs. A. Harper, Sons & Bean, Limited, Dudley and Tipton, and also the works of Messrs. Bagshawe & Company, Limited, Dunstable.

"The financial position of the Branch is satisfactory, and the last statement of the Hon. Treasurer shows a balance in hand of just over £30. Subscriptions do not come in so well as they should, and there are several instances of arrears being unattended to. Attention is being given to some of these instances. The Social Fund balance in hand is over £5.

XUM

"At the last Branch Council meeting it was decided to make the following nominations for your final confirmation to-day of officers for the ensuing session:—Branch-President, Mr. V. C. Faulkner; Vice-Presidents, Messrs. Pierce and Shaw; Hon. Secretary, Mr. H. G. Sommerfield; Hon. Treasurer, Mr. R. J. Shaw; Councillors. Messrs. Shillitoe, Clark and Hall have two years' office to run; Col. Cheesewright, Messrs. Cole Estep and Maybrey, have one year to run; Messrs. Hand, Cleaver and Brown retire now, and these offices are consequently vacant; Auditors, Messrs. Bartlett and Cole Estep."

The Branch-President said that although the Council had nominated various gentlemen for office for the ensuing session, it did not by any means follow that the Branch need accept them, and it was open for anybody to propose any alteration. With reference to the three members of Council who retired, namely, Messrs. Hand, Cleaver and Brown, the first two offered themselves for re-election, but Mr. Brown, who had retired from the foundry industry entirely, did not offer himself, and a nomination was asked from the members to fill this vacancy.

Mr. W. B. Lake moved the adoption of the list of officers and Council read out by the Secretary.

Mr. Wesley Lambert seconded, and the motion was carried unanimously.

The Branch-President then asked for a proposition from the meeting to fill the vacancy on the Council caused by the retirement of Mr. Brown, the nominee to serve for three years. Some time ago, he added, there was an election, in which the names of Mr. Hall and Mr. Gibbs were voted upon, and it was a very near ballot. On the present occasion, therefore, perhaps it might assist if he suggested that Mr. Gibbs be invited to fill the vacancy.

Mr. A. R. Bartlett seconded, and the motion was carried.

The Branch-President, on behalf of himself and the members of Council, expressed his sincere thanks for the confidence shown in them by their re-election, and mentioned that the attendance book showed that 70 per cent. of the Council turned up at every meeting. Unfortunately, that could not be said of the ordinary members, the attendances being, roughly, 25 per cent. Therefore he might say that the Branch had a band of willing workers to represent them.

With regard to the delegates to the General Council, as the Branch had a membership of over 150 it was entitled to three delegates, and he proposed the re-election of Mr. Shaw, Col. Cheesewright and Mr. Wesley Lambert. This proposal was seconded, and carried unanimously.

This concluded the business of the annual general meeting. The company was then entertained to tea by Messrs. Bagshawe.

Appreciation Expressed.

The Branch-President proposed a hearty vote of thanks to Messrs. Bagshawe for the kind reception given to the members of the Branch that afternoon, and he coupled with the vote the names of Mr. Gerald Bagshawe and of their esteemed member Mr. Gardom, who had been instrumental in getting the members of the Branch down to the foundry that afternoon. A visit of this sort entailed work for many people, and the whole of the staff had gone out of their way to place their experiences and time at the disposal of the visitors. He was quite sure Mr. Bagshawe would have far rather been cutting the grass or playing golf than being in the works on such a fine afternoon, but at the same time he knew Mr. Bagshawe was quite pleased to have seen members of the Branch, and therefore he moved a very hearty vote of thanks to Messrs. Bagshawe.

The vote of thanks was carried with acclamation.

Mr. Gerald Bagshawe, in acknowledging the vote of thanks, said in the first place that if there were any who had been round the works that afternoon who would like to come down again individually at some future time he was only too pleased to give an open invitation to them all. If they would give him a day or two's notice things could be arranged so that matters could be explained in greater detail than was possible in conducting a party round the works. At the same time he had been very pleased that the Branch had visited the works, and although perhaps the works were not able to show quite so much as some larger ones in the country, yet they would all agree that it was not always the big things that counted. It was the little things, the details, that made all the difference in the successful running of any business or foundry, because, after all, every foundry, in general principles, was the same, whether it was malleable, grey iron or brass. The final result largely depended upon the details, and upon these depended the question of whether the foundry was making a profit or a loss. Obviously, these details could be explained better with the workpeople at work. There was, for instance, the casting conditions, the casting of the metal, the making of the boxes, and the whole system of the works generally, which could be better understood when it was in actual operation. It was difficult to show all these to large parties whilst the works were in operation, but if anyone cared to come down individually at any time the fullest information would willingly be given to him. A small works like theirs, of course, could not do what was done in two of the largest works in America which he had been over. For instance, he had seen the Ford factory where there were special arrangements for showing the works to visitors, which was part of the publicity scheme. A small firm like Messrs. Bagshawe could not do that, although they were always pleased for people to come down and see the works. From the technical point of view there were probably many questions which the visitors would like to put which he probably would not be able to answer. In any case, however, the information required would be obtained for anybody; at the same time, Mr. Gardom would now be willing to answer any questions that might be put. He thanked the visitors for their kindness in coming down, and hoped they had had a pleasant afternoon.

The Branch-President remarked that no special preparation had been made for the visitors in the foundry that afternoon, and he was assured by people who had been there on many occasions that the general cleanliness of the whole place was a regular feature of the works all through the week.

Technical Details.

Mr. Gardom remarked that one of the visitors had commented on the fact that there did not seem to be much work in hand. He wished to thank him for that, because he regarded it as testimony to the success of the system upon which the works were run. The reason why a lot of work was not seen lying about the foundry was that it was a principle never to keep customers waiting. In all metallurgical work time and temperature were two of the essential factors, and in malleable work it was impossible to get a fair-sized order through, from the time of receiving the pattern, under say three weeks. If the work was hung up in stores, for example, afterwards, it might mean another week, and that had to be avoided, and that was the reason why much work was not seen lying about. There had been seen five annealing ovens going, and these took somewhere about 45 tons, so that the firm was doing something. The works were as large as a number of other malleable firms in various parts of the country, and in the present case it was all repetition work. The firm prided itself on studying the workpeople, perhaps as much for the benefit of the product as for anything else, and in that connection he would like to draw attention to one feature of the works—viz., in the grinding shop the belt drives were horizontal instead of overhead. The reason for that was that it had been found that although the horizontal drive took up more room, it allowed much more air space—which was important—and the output of the machines was found to be 10 per cent. greater than with the overhead drive. Another feature was that the grinding machines were all fitted with ball bearings, and it was possible for a person to pull the whole series of 14 machines round by hand quite comfortably. There was a life of from 10 to 12 months for the bearings, and considering that the machines were worked by unskilled men that was a good result.

Company News.

Wm. Simons & Company, Limited.—Dividend and bonus, 8¾ per cent. making 12½ per cent. for year.

A. Grabham & Company, Limited, 373, Essex Road, London, N.—Capital £3,000. Engineers, etc. Director: A. Grabham.

C. A. T. Cable Company, Limited, 175, Piccadilly, London, W.—Capital £1,000. Directors: P. Adair, A. Collins and R. B. Turner.

F. A. Jones (Liverpool), Limited, 7, Strand Street, Liverpool.—Capital £8,000 in £1 shares. Engineers. Directors: F. A. Jones and W. Hall.

John I. Thornycroft & Company, Limited.—Interim dividend, 3 per cent. on cumulative preference shares, less tax.

Wellman Smith Owen Engineering Corporation, Limited.—Final dividend, 5 per cent., making 10 per cent. for year, less tax.

Park Gate Iron and Steel Company, Limited.—No depreciation written off; profit, £8,104; applied to reduce balance of loss brought forward.

Richard Hill & Company (Middlesbrough), Limited.—Interim dividend on 6 per cent. cumulative preference shares, but no dividend on ordinary shares.

T. T. Crook, Limited, Stanley Ironworks, Derby Street, Bolton.—Capital £6,000 in £1 shares. Engineers. Directors: W. H. Crook, W. Crook and T. A. Crook.

Southgate & Sons, Limited.—Capital £2,000. Metal merchants, etc. Directors: W. H. Southgate (permanent) and P. Southgate (secretary), both of 16, Long Street, Ipswich.

G. W. Mottram, Limited, 52, Corporation Street, Manchester.—Capital £5,000 in £1 shares. Scrap merchants, ironmasters, colliery proprietors, etc. Director: G. W. Mottram.

Automatic Pressings, Limited.—Capital £1,000 in £1 shares. Manufacturers of belt fasteners, etc. Directors: J. H. Beasley, Highfield House, Blackheath, Birmingham, and G. N. Hall.

William E. Challis, Limited, Barton House, 66, Deansgate, Manchester.—Capital £1,500. Constructional engineers, etc. Directors: W. E. Challis, A. C. Johnston, A. C. Tunley and F. Webb.

Manganese Bronze and Brass Company, Limited.—Interest on first mortgage debentures, £7,188; brought forward, £11,762; credit balance, £3,982, carried forward.

Tweedale & Smalley, Limited.—Net profits, £61,460; brought forward, £129,127; final dividend, 12½ per cent., making 25 per cent. for twelve months; carry forward, £78,087.

Nobel Industries Company, Limited.—Dividend, 8 per cent. on ordinary shares for 1923; brought forward, £510,000; special investment reserve, £100,000; carry forward, £650,000.

Mirrlees, Bickerton & Day, Limited.—Net profit, £25,946; brought forward, £3,390; dividend, 7½ per cent. per annum, less tax, on ordinary share capital; reserve, £5,000; carried forward, £6,779.

British Thomson-Houston Company, Limited.—Profits, £451,778; brought forward, £236,671; general reserve, £50,000; depreciation, £135,440; dividend, 6 per cent. on ordinary shares; carry forward, £210,863.

Progress Engineering Company (Ossett), Limited, Progress Engineering Works, Dewsbury Road, Ossett.—Capital £3,000 in £1 shares. Directors: W. H. Chapman, H. Chapman, J. W. Chapman and F. Booth.

W. Rainforth & Sons, Limited, Agricultural Hall, Monks Road, Lincoln.—Capital £25,000. Machinery manufacturers, etc. Permanent directors: S. Rainforth, Dr. J. J. Rainforth, J. Harris and Miss Z. J. Rainforth.

Cylinder Castings, Limited.—Capital £10,000 in £1 shares (5,000 7 per cent. cumulative preference). Directors: W. H. Moore, T. F. Hardyman (managing), F. J. Dawe, A. P. Winsor and R. H. Moore, 6, Charlebury Road, Oxford.

Willenhall Iron Company, Limited, Spring Vale Street, Springbank, Willenhall.—Capital £4,500 in £1 shares (2,000 6 per cent. cumulative preference), to acquire the goodwill and certain of the assets of the Springbank Iron Company, Limited, etc.

John Livingston & Sons, Limited.—Capital £5,000 in £1 shares, to acquire the business assets and liabilities of Livingston's Estate, Limited, of Middlesbrough. Brassfounders and engineers, etc. Solicitors: P. H. Monk, 13, Queen's Square, Middlesbrough.

Alnwick Construction and Engineering Company, Limited, The Foundry, Alnwick.—Capital £10,000 in £1 shares, to acquire the business lately carried on as the Alnwick Foundry and Engineering Company, Limited. Directors: M. A. Sell and G. S. Sell.

Robert Heath & Low Moor, Limited.—Profit, £70,576; debenture interest, £60,714; available, £9,862; debit of profit and loss account brought forward, £33,483; balance carried forward to debit of profit and loss account, £23,621.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

"The Manufacture of Pearlitic Cast Iron for High-Temperature Engines."

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We notice that in the above-mentioned Paper by Mr. A. Marks, published in your issue of May 15, a comparison is made between pearlitic cast iron and centrifugally cast material. We think, however, that Mr. Marks is not fully acquainted with present practice of making castings by this method. When centrifugal castings are produced in a hard, white condition (either by adjusing the chemical composition or using a cooled mould), a very drastic annealing is necessary, and this treatment invariably breaks down all the combined carbon and leaves a material with a structure somewhat similar to malleable cast iron. While such material may be very suitable for articles like water pipes, etc., it is useless for any part which is subjected to abrasion of any kind on account of the excessive wear due to the absence of combined carbon.

We therefore feel that it would be a very difficult matter to get centrifugal castings to withstand wear satisfactorily if annealing had to be resorted to, and we think it desirable that it should be pointed out that for castings for internal-combustion engines this method is not satisfactory.—Yours, etc.,

Pp. THE BRITISH PISTON RING COMPANY, LIMITED,
WILLIAM A. OWBRIDGE,
Managing Director.

Holbrook Lane, Coventry,
May 27, 1924.

Trade Talk.

THE LECONFIELD IRON ORE MINE, Cleaton Moor, and the Lamplugh Iron Ore mine are now working intermittently. About 100 men are employed at each mine.

TEN "PACIFIC" type locomotives have been ordered for the Leopoldina Railway of Brazil from Beyer, Peacock & Company, Limited, of Gorton, Manchester.

MR. H. D. MILES, a past-president of the American Foundrymen's Association, is now in Great Britain, and intends to take part in the Newcastle Conference of the Institute of British Foundrymen. Mr. Miles is connected with the Buffalo Foundry Machine Company of Buffalo, New York.

THE UNDERGROUND RAILWAY COMPANY have placed further contracts for the construction of 127 new cars for service on the Edgware and City and South London and Morden lines as follows:—Metropolitan Carriage Wagon & Finance Company, 52 motors; Birmingham Railway Carriage & Wagon Company, 50 trailers; Cammell, Laird & Company, 25 control trailers.

THE YORKSHIRE BRANCH of the Institution of Mechanical Engineers held a meeting at Hull on May 16. Lt.-Col. E. Kitson Clark took the place of the branch chairman, Prof. G. F. Charnock, who was unable to be present. By invitation of the London and North Eastern Railway a close inspection of the King George Dock was possible.

MR. W. GRIFFITHS, works manager, has died at his residence Gwernllwynchwyth, Llansamlet. He started his commercial life at the offices of the Grovesend Tinplate Company at its inception, and afterwards became secretary of the Fairwood Tinplate Company, and subsequently manager of the old Landore Tinplate Works.

HENRY ROBB, LIMITED, ship repairers and engineers, Leith, have purchased from Hawthorns & Company, Limited, one of the latter firm's yards at Leith—the Victoria Shipbuilding Yard. Messrs. Robb will build in this yard dredgers and pontoons, such as they have built in the past at the Imperial Dock, where the vessels had to be lowered into the water by a crane. At the new yard they will be launched from slipways. The firm are also to build cargo steamers up to about 5,000 tons gross.

IN ADDITION to the heavy sludge pump supplied by Hollings & Guest, Limited, Thimble Mill Lane, Birmingham, last year to the Birmingham Tame and Rea Drainage Board, the company have now received a further order for a similar set of hydraulic pumps, also to be installed at the Saltley Drainage Works. The pump is of the 3-throw single-acting piston type, having three pistons, and capable of pumping 500 gallons of sewage sludge per minute when delivering, and 1,000 gallons of sludge per minute when circulating.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Only a very moderate volume of business was passing in last week's Cleveland iron markets, so far as home consumers are concerned, although on the export side the tonnage of shipments for the current month promises to largely exceed the figures reported for April. The outlook, however, with regard to home demand may be considered perhaps more encouraging. There is evidence of a recovery in shipbuilding, and this should react favourably upon business in the foundries. Moreover, it will mean the absorption of more iron in the iron and steel works, thus reducing the quantity available for the open market. The export position is rather more difficult to diagnose. There is still a fair inquiry, but it is only for moderate quantities, which by no means represent the full requirements of foreign customers. At this week's market prices were steady. No. 3 G.M.B. could be done at 91s., with No. 1 96s., No. 4 foundry 90s., and No. 4 forge 89s. per ton.

In the hematite section, while the outlook in the home trade is a little better, export inquiry has fallen off, owing to the decline of the franc, and the generally difficult financial conditions on the Continent. Consequently, while the quotation for East Coast mixed numbers stood nominally at 98s. 6d., business for suitable quantities could be done without difficulty at 98s. per ton. The premium for the No. 1 quality was 1s. per ton. On the West Coast, Bessemer mixed numbers continue to be quoted at £5 7s. 6d. delivered at Glasgow, £5 12s. 6d. at Sheffield, and £5 17s. 6d. at Birmingham.

MANCHESTER.—The demand for foundry iron in this district continues on a moderate scale, consumers being hampered by the dearness both of raw material and fuel, while the threat of a strike for higher wages by the workers in the industry adds to the embarrassment of the position. There has been some weakening in prices in this market, and some sellers of Derbyshire iron have come down to 93s. 6d. per ton at the furnaces, but others still keep to 95s., which means 103s. per ton in Manchester. For some brands of Scotch iron delivered locally 118s. 6d. per ton is quoted, while for ordinary good Scotch No. 3 the makers' price is equal to 117s. per ton, delivered locally.

THE MIDLANDS.—Local consumers of foundry pig, finding orders for castings very scarce, are restricting buying to the barest requirements, and though in exceptional cases works are busy this is certainly not the general rule. Most of the larger ironfounders bought a month or so back for their estimated requirements up to the end of June, and it is not likely that they will be in too great a hurry to go into the market again, seeing that the present figures of Northants, Staffs. and Derbyshire iron are none too firm. Current prices are as indicated below:—Derbyshire No. 3 foundry, 92s. 6d. to 95s.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 91s. 6d.

SCOTLAND.—Business in the Scottish iron markets remains more or less stagnant, with only moderate quantities for prompt delivery in demand. The nominal price of No. 3 foundry is unchanged at 100s. at the furnaces, but for actual business concessions on this figure can be obtained. Foundries report that they are not getting in any increased number of orders, and for this reason have no confidence in making good-sized contracts.

The Association of German Iron Foundries, in consideration of the increased costs of production, have raised the price of all trade castings by 10 per cent. as from April 25. The Association states this price increase does not, however, suffice to cover the costs of production of a great many of the foundries.

Finished Iron.

In the South Staffordshire markets for this class of material business remains quietly steady, with prices unchanged, at £15 f.o.t. for marked bars, £12 10s. to £13 for crown, and £11 15s. to £12 for nut and bolt quality. The makers of crown iron are having a hard fight to maintain the figure of £13, as the competition is very keen indeed. Foreign nut and bolt iron is being offered here at £8 15s. to £9 delivered station or sidings for June-July delivery, perhaps.

Steel.

The outlook in the steel industry at the moment appears somewhat uncertain, although in certain branches a more favourable view of future conditions is entertained. The demand for acid billets shows a trifling improvement, but for all classes of basic billets the inquiry is very small. Users appear to be very well stocked, and the supplies of Continental billets, bought when they were much cheaper than British billets, are not yet exhausted. The market for alloys continues quiet, with ferro-manganese, 76/80 per cent. loose, quoted £17 per ton, the same price being current for export. The continued fall in block tin values has been followed by a similar movement in tinplates, which are now quoted at the official minimum of 23s. 6d. per box, f.o.b. Bristol Channel ports.

Scrap.

Movements in the various markets for scrap metal continue uneventful, with demand as a rule on a very limited scale. In Lancashire, dealers have, in many cases, rather more cast scrap in hand than is quite convenient, and naturally they are inclined to offer prices, when buying, which leave them a larger margin of apparent profit than used to be thought sufficient. In foundry scrap the amount of business doing is comparatively small, and the prices paid seem to range from 78s. 6d. to 90s. per ton delivered, or say, roughly, from 12s. 6d. to 15s. per ton below the cost of foundry pig-iron. In Scotland, old cast-iron railway chairs are in better demand, together with cast-iron scrap, in pieces not exceeding 1 cwt., at 97s. 6d. per ton. For machinery or first-quality cast-iron scrap, in handy pieces, 2s. 6d. per ton more might be obtained. Ironworks metal is about 90s. to 92s. 6d. per ton, and light cast-iron scrap is 80s. per ton, while for light cast iron and fire-bars mixed, 77s. 6d. per ton is quoted. The foregoing prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Following more favourable American advices last week, values of standard copper maintained a steadier tendency, but, on the whole, market movements have been quiet. The difficulties still experienced in re-establishing European trade stability are, however, unfavourable to an expansion of demand in the chief centres of Continental industry, while the necessity experienced by over-stocked German copper importers for selling odd parcels at cut rates to provide funds for immediate use is also an additional factor of unsettlement. Current quotations:—*Cash*: Thursday, £61 5s.; Friday, £60 17s. 6d.; Monday, £61 2s. 6d.; Tuesday, £61 5s.; Wednesday, £61 12s. 6d. *Three Months*: Thursday, £62 2s. 6d.; Friday, £61 15s.; Monday, £62; Tuesday, £62 2s. 6d.; Wednesday, £62 10s.

Tin.—The trend of values in the market for standard tin has again been downwards, the current quotation now showing a loss of nearly £100 per ton during the past few months, and within a few pounds of the level for the corresponding period of last year. It would appear that with the fall in values there has been a change in policy with regard to the pooled stocks in the East. It is unlikely that the parties concerned will feel inclined to liquidate at the present level, and the announcement that sales made by the Federated Malay States Government up to April 30 only amounted to 6,175 tons apparently substantiates this view. Current quotations:—*Cash*: Thursday, £206; Friday, £201; Monday, £206 15s.; Tuesday, £208 10s.; Wednesday, £213 5s. *Three Months*: Thursday, £205 10s.; Friday, £200 10s.; Monday, £206 5s.; Tuesday, £207; Wednesday, £211 10s.

Spelter.—With regard to this metal, Rudolf Wolff & Company report that the market has, on the whole, developed a better tone, following some improvement which had taken place in demand on the part of consumers, influential support, and some bear covering, producers on the Continent at the same time showing a certain reserve. Belgian works are reported to be fairly well sold, at any rate for the next month or so. Some improvement is reported in the market in the U.S.A. Current quotations:—*Ordinary*: Thursday, £30 7s. 6d.; Friday, £30 6s. 3d.; Monday, £30 12s. 6d.; Tuesday, £31 3s. 9d.; Wednesday, £31 12s. 6d.

Lead.—The market for soft foreign pig has developed rather unsettled conditions, and while consumption is still reported to be good, demand is not particularly urgent, and supplies, on the whole, seem sufficient to meet requirement. Current quotations:—*Soft foreign (prompt)*: Thursday, £29; Friday, £28 12s. 6d.; Monday, £29 17s. 6d.; Tuesday, £29 15s.; Wednesday, £30.

The Argentine Foreign Purchases Commission will arrive in England in June to make purchases of armaments and munitions for the Argentine Army. Purchases to be effected comprise armaments and munitions, aviation material, and plant for munition factories.